DOCUMENT RESUME

ED 323 912 IR 014 535

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TITLE Proceedings of Selected Research Paper Presentations at the Convention of the Association for Educational Communications and Technology and Sponsored by the Research and Theory Division (Anaheim, California, January 31-February 4, 1990).

INSTITUTION Iowa State Univ. of Science and Technology, Ames. Coll. of Education.

PUB DATE 90

NOTE 739p.; For the individual papers, see IR 014 536-582. For the proceedings of the 1989 conference, see ED 308 805.

PUB TYPE Collected Works - Conference Proceedings (021) -- Viewpoints (120) -- Reports - Research/Technical (143)

EDRS PRICE MF04/PC30 Plus Postage.

DESCRIPTORS *Cognitive Processes; *Cognitive Style; Educational Media; *Educational Technology; Hypermedia; *Instructional Design; Instructional Development; Intermode Differences; Learner Controlled Instruction; Learning Strategies; *Media Research; Research Methodology; Visual Learning

IDENTIFIERS Media Characteristics

ABSTRACT

Current issues in educational communications and technology are addressed in this collection of 47 conference papers in which research reports predominate. Topics discussed include factors related to the learner, e.g., learning strategies, information processing, spatial ability, cognitive style, and cognitive strategies. Presentation format and media and stimulus characteristics are also addressed, including illustration types, graphics in courseware design, text layout variables, feedback, and synthesizing strategies. Several papers examine educational media such as videodiscs, videotapes, and microcomputers. Additional papers discuss the design of instructional visuals, the use of video to study cognition, learner versus program control of interactive media, trends and issues in educational technology, assessment of structural knowledge, applications of hypermedia, distance education for teacher training, facilitating the acquisition of clinical reasoning skills, Kuhnian paradigms in educational technology research, and advancements in instructional design theory. References and data tables are included with many papers. Author and descriptor indexes are provided. (GL)

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PROCEEDINGS OF SELECTED RESEARCH PAPER PRESENTATIONS

at the 1990 Convention of the
Association for Educational Communications and Technology
and sponsored by the Research and Theory Division
in
Anaheim, California

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PREFACE

For the twelfth year, the Research and Theory Division of the Association for Educational Communications and Technology (AECT) is publishing these Proceedings. Papers published in this volume were presented at the national AECT Convention in Anaheim, California. A limited quantity of this volume were printed and sold. It is also available on microfiche through the Educational Resources Information Clearinghouse (ERIC) system.

REFEREEING PROCESS: All research papers selected for presentation at the AECT Convention and included in this Proceedings were subjected to a rigorous blind reviewing process. Proposals were submitted to Steven Ross and Gary Morrison of Memphis State University or Marina McIsaac of Arizona State University. All references to author were removed from proposals before they were submitted to referees for review. Approximately fifty percent of the manuscripts submitted for consideration were selected for presentation at the Convention and for Publication in these Proceedings. The papers contained in this document represent some of the most current thinking in educational communications and technology.

This volume contains two indexes covering this volume. The first is an author index; the second is a descriptor index. This year and 1989 are included. The two indexes will be updated in future editions of this Proceedings. The index for volumes 1-6 (1979-84) is included in the 1986 Proceedings, and the index for volumes 7-10 is in the 1988 Proceedings.

M. R. Simonson
Editor

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ERIC ED NUMBERS

YEAR	LOCATION	ED NUMBER
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1980	Denver	194061
1981	Philadelphia	207487
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1983	New Orleans	231337
1984	Dallas	243411
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AECT began as the Department of Audio-Visual Instruction at the National Education Association in 1923, in the days when visual aids were blackboards and easels. In 1947, as educators were adapting technology used to train World War II service personnel for the classroom, the name of the organization became the Department of Visual Instruction (DAVI). Twelve years later, DAVI became an affiliate of the NEA and finally the autonomous association, AECT, in 1974.

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Title:

Learner Control of Review in Computer Assisted Instruction within a Military Training Environment

Author:

Gary W. Allen

0 1

Learner Control of Review in Computer Assisted Instruction within a Military Training Environment

In 1988 the United States Army planned on spending in excess of 1.2 billion dollars on individual training, and in 1989 that budget increased to 1.3 billion dollars (Office of the Director of the Army, 1987). Although these dollars represent only a small fraction of the total Army budget, they indicate that the Army's commitment to training is extensive. In the face of Congressional pressure to limit the Defense Budget as part of a general plan to bring the National Debt under control, the US Army must make every effort to increase training efficiency and effectiveness. A major source for achieving better quality training has been the use of instructional technology which Gagne´ (1987) defines as practical techniques of instructional delivery that systematically aim for effective learning.

The issue of efficiency in the training environment has a long tradition in the Army. Many of the developments in instructional technology used in the educational environment at large came from research conducted for the military since World War I (Noble, 1988). The use of computers as a medium of instructional technology has been a major contribution to the developmental progression of this technology. Most recently the Army has commenced an effort to integrate the use of personal computers to deliver instruction at various training institutions. Invariably the success of the Electronic Information Delivery System (EIDS) will rest on the quality of the instructional software, officially referred to as Interactive Courseware (ICW) (TRADOC, 1987).

One method of making a qualitative change in ICW is improving the nature of interactivity between the student and the computer. A feature of interactivity that can be manipulated by the instructional designer is the amount of learner-control afforded by the courseware. Over the years the term, learner-control, has meant different things to instructional designers. The first educational use of the term learner-control (Mager & Clark, 1963) referred to the student's ability to sequence the content of a particular course of instruction. Later, allowing the student the ability to control the pace of instruction came under the heading of learner control. Research has also been done that allows the learner to control the questions and style of instruction (McCann, 1981). Because the term learner control can be used in reference to different features of ICW, a descriptor is used to qualify type (e.g. learner-control of review).

The role which learner control plays in the success of ICW is not entirely clear. Several studies have suggested that learner control can be as simple as control of pace and be very successful in terms of achievement (Park & Tennyson, 1983; Ross & Rakow, 1981 among others). A meta-analysis by Steinberg (1977) indicates that external control of instruction by the computer is as effective as learner control and has the added advantage of taking less time to complete, which has implications for the efficiency of instruction. Other studies have suggested that giving the learner more control over the instruction has produced positive results (Merrill, 1980; Hannafin & Colamaio, 1987). One advantage for learner control that seems to be consistent is that students show a better attitude toward the instruction when they have greater control, which in turn increases motivation (Sawyer, 1985). Because of these inconsistencies, Snow (1980) has put forth the argument that the conditions of effective learner control still merit study. The result is that a primary emphasis of CAI design research has been on learner control of pace and content sequence, but there has been little significant research on providing the learner with the ability (control) to review content when the student feels a need for review.

The present research was prompted, in part, by design constraints noted in two related research projects (Ho *et al.*, 1986; Kinzie *et al.*, 1987). In the study conducted by Ho *et al.* (1986) the ICW did not include embedded questions as a part of the instructional design. One explanation for the significance the review option that study achieved, was possibly due to the absence of review questions. The Kinzie *et al.* (1987) study compared program and learner controlled review of embedded questions after an incorrect response. The study achieved significance which favored the use of learner control. Yet, that research leaves open the question of whether a review is better than not having a review. The present study addressed both issues.

The theoretical base for the research questions addressed came from a review of past CAI research, research based ICW design factors, map reading, and military training. More recently several studies have examined different design factors including; embedded questions, feedback, learner control, screen design, and the use of text. The design component investigated in the present project was the use of review; which are those activities that make use of the content after the original learning has occurred (Blair *et al.*, 1968). The research used to support the hypotheses came from a synthesis of findings found in research concerning traditional teaching techniques, open-book testing, and use of review in ICW. The conclusion was that there is sufficient evidence to suggest that a review option could improve a students achievement on fact, procedure, and problem solving questions without adversely effecting efficiency.

The central research question was: "Does providing students with an option to review content in ICW, when attempting to answer embedded questions, improve their achievement on a posttest without adversely effecting the amount of time it takes to complete the instruction?" The courseware made use of fact, procedure, and problem solving questions, which represents three different types of learning (Schaffer &Hannafin, 1986).

Independent and Dependent Variables

The independent variable for this study was analyzed for effect in relation to five dependent variables. The independent variable was learner control of a` Content Review Option (CRO). A course on military map reading, that contained eight lessons, was converted, using research based design principles, into two versions of CAI from an existing programmed text. In version one, Limited Access to the Content Review Option (LACRO) (Fig. 1), subjects had access to a summarized review of a lesson's content after the lesson had been completed but before encountering the embedded questions. In version two, Open Access to the Content Review Option (OACRO) (Fig. 2), subjects had access to the review at the end of a lesson, when presented a question, and after receiving feedback to a question response. The five dependent variables were achievement [four factors: 1) fact questions; 2) procedure questions; 3) problem solving questions, and 4) total score], instructional time, attention time, review time, and acquisition rate.

Instrument

The recall posttest was a 21 item, multiple choice test. The test covered seven lessons found in the ICW. Each sub-lesson had a fact, procedural, and problem solving type question. The test was patterned after a test designed by the U.S. Army. The test was reviewed by a panel of three independent subject matter experts (inter-rater reliability = .95), and went through post-hoc reliability testing ($\alpha = .68$). The following criteria were used for the design of each question (Hannafin & Colamaio, 1987):

Factual - Requires the literal, verbatim recall of information presented during the lesson.

Procedural - Requires the integration and transfer of the lesson's factual information to a series of related tasks.

Problem Solving - Requires the application of facts or procedures to the solution of novel problems.

In addition to the posttest, an informal post-treatment questionnaire was completed by each subject. The questionnaire had seven questions relating to the subjects use of the CAI and review option. The results from this survey are covered later.

Subjects

The subjects used in this study were 58 Army ROTC cadets drawn from the MS I (freshman), MS II (sophomore), and MS III (junior) classes at the University of Kansas. An additional 12 subjects were drawn from the undergraduate teacher program in the School of Education. The subjects were randomly assigned to groups and the groups were randomly assigned to treatments.

Data Treatment

A two-group design was used for this research. The dependent variables for achievement, and attention time were analyzed using MANOVA procedures. ANOVA procedures were used to analyze the acquisition rate data. ANOVA procedures were used to analyze the instructional time data, and ANCOVA procedures were used to analyze the effect of review time on instructional time. The level of significance was set at .05.

Results

Hypothesis One: Posttest

The null hypothesis states that there is no significant difference in achievement between the groups as measured by the achievement posttest. The score recorded has a possible range of 1 - 21 and is one of four scores recorded using one posttest. The sub-scores for fact, procedure, and problem solving questions are discussed in hypothesis two.

To test Hypothesis One, a MANOVA was done on the posttest data using the SPSSx statistical package on the University of Kansas VAX computer system. The Hotellings criterion for multivariate analysis yielded, $F(4,65) = .659$, $p = .623$, which was not significant. Mean scores, standard deviations, and sample sizes for the two groups are reported in Table 1. The results of univariate F-Tests are shown in Table 2. Hypothesis one was not rejected.

Hypothesis Two: Fact, Procedure, and Problem Solving

The null hypothesis has the following three parts. One, there is no significant difference on achievement for fact type questions between the two groups. Two, there is no significant difference on achievement for procedure type questions between the two groups. Three, there is no significant difference on achievement for problem solving type questions between the two groups. The MANOVA returned, $F(4,65) = .659$, $p=.623$, which was not significant. Descriptive statistics are presented in Table 3, and inferential statistics are included in Table 4. Hypothesis Two was not rejected.

Hypothesis Three: Acquisition Rate

The null hypothesis states that there is no significant difference in acquisition rate between the two groups. Acquisition rate was based on the recall to instructional time ratio (total points on posttest divided by instructional time in minutes and seconds). Acquisition rate was a time-based indicator of learning efficiency for the two treatments (Schaffer & Hannafin, 1986). A one-way ANOVA, using the MYSTAT (SYSTAT, Inc.) computer package on a Macintosh SE, was done on the acquisition rate data. The computed ANOVA for the difference between the treatment groups was, $F(1, 68) = 3.455$, $p=.067$. Therefore, hypothesis three was not rejected. Means, standard deviations, and number of cases are displayed for each group in Table 5. The ANOVA summary is presented in Table 6.

Hypothesis Four: Attention Time

The null hypothesis stated there is no significant difference in attention time between the two groups. The data is divided into nine parts. The first eight parts was the time spent on each lesson. The ninth data point was the cumulation of parts 1 through 8. MANOVA used to analyze these data yielded the following, $F(9,60) = 1.139$, $p=.351$, which was not significant. Hypothesis four was not rejected. Means, standard deviations, and cell sizes are shown in Table 7. Relevant univariate F-tests are included in Table 8.

Hypothesis Five: Instructional Time

The fifth hypothesis states that there is no significant difference in instructional time means between the two groups. Instructional time was the amount of time it takes a learner to complete the entire course of instruction. Measurement commenced when the first instructional screen was encountered and terminated when the last screen of the lesson was completed. An ANOVA was performed which produced a significant instructional time effect, $F(1, 68) = 4.309$, $p=.042$. Therefore Hypothesis Five was rejected. To further test the probability that the review option was the cause for the significant difference in Hypothesis Five an ANCOVA, using the MYSTAT statistical package on a Macintosh SE computer, was done using the review time data as the covariate. The computations resulted in, $F(1, 67) = .770$, $p=.383$, which was not significant. Means, standard deviations, and cell size are reported in Table 9. ANOVA, and ANCOVA summaries are shown in Tables 10 and 11 respectively. The interpretation is that the OACRO group spent significantly more time using the map reading CAI and that this increase in time was because of review time.

Informal Data

After the subjects took the posttest they were asked to respond to seven questions. The responses to those questions are described in the following paragraphs.

Question 1; "Were you aware of having the option to review the course material?" Responses indicate that 95.7% of all the subjects knew they had the option to review the material.

Question 2; "Did you know when you could use the review option?" A majority of respondents (97%), that answered positively in Question 1, replied positively to question 2. The high percentage of positive responses to these two questions led to the conclusion that retention of the null hypotheses was not because of subject ignorance of the content review option.

Question 3; "Do you think you would use the review more often if you could see the questions before deciding if you wanted to review?" This question was only directed to those subjects in the group that had limited access to the review. The majority of subjects (81.3%) responded "Yes" to this question. This response compares favorably with the behavior of the subjects in the open access group since 91% used the review after they saw the questions.

Question 4; "What type of question did you use the review on most often?" This question was directed to the subjects in the group that had open access to the review. The tally indicates that; 8.6% did not use the review when the question was presented, 17.1% used the review only on fact type questions, 2.9% used the review only for procedure type questions, 11.4% used the review only for problem solving questions, 57.1% used the review on both fact and procedure type questions, and 2.9% used the review for all the types of questions. In general, students accessed the review most often for questions which require the use of rote memory.

Question 5; "Do you think you would use the review more often if the questions were fill-in-the-blank, or short answer?" As with Question 4 this question was directed at only the subjects in the open access group. The majority (74.3%) of the OACRO subjects responded positively to this question. This response rate suggests that the use of multiple-choice questions effected a subject's decision to use the review option.

Question 6; "What changes in training conditions do you believe would cause you to use the review more often?" Two conditions emerged. A minority (21%) of all the subjects indicated that if they were required to spend a specified amount of time in the training session - which exceeded the amount of time it would normally take to complete the instruction - they would use the review. A majority (61%) of all the subjects indicated that if a minimum standard of achievement was established for passing then they would probably use the review more often. This indicates that the conditions under which the research was conducted influenced a subject's decision to use the review. The other 18% of the subjects gave no answer to this question.

Question 7; "Did you have any problems using the courseware on the computer?" A majority (93%) of all the subjects indicated that they had no difficulty using the CAI medium employed in the present research. The researcher concludes that the user interface of the instructional medium did not adversely effect achievement.

Conclusions

Regarding achievement, it was concluded that providing a content review option did not produce a significant difference between the groups. This was also true for the three types of questions used to make up the posttest. This indicates that the effect the use of review questions had on student achievement was not enhanced when a content review option is added to the instructional design. Since the content in this study is comparable to the content used in the studies conducted by Ho *et al.* (1986) and Kinzie *et al.* (1987) the present research raises questions regarding generalizations made in those previously mentioned studies. The Ho *et al.* (1986) study declared that the results indicate the use of review, in the form of a lesson summary, is an effective instructional design strategy. Since that study did not use embedded questions, which is considered a ICW design imperative (Alessi & Trollip, 1985; Wager & Wager, 1985; Hannafin & Peck, 1988), then it is reasonable to question if the same results would be realized if embedded questions were used in conjunction with the review option. Kinzie *et al.* (1987) recognized that research conducted in this area should be done within the context of sound instructional design. The review option designed for that study complimented the use of embedded questions but, the review could only be accessed after an incorrect answer, which may be a design limitation rather than a design flaw. On the basis of their results they stated that learner control of review was a practical design factor. Kinzie *et al.* (1987), however, did not address whether or not review plus embedded questions is more effective than embedded questions alone.

A comparison of the results of these two research efforts suggests that installing a content review option in addition to the use of embedded questions would be an effective ICW design. But the results of the present study indicates the positive effects noted in the Ho and Kinzie studies are not additive. The effects of review may be absorbed by the effect that the use of embedded questions has on student achievement regardless of the type of question used.

The results of the present study also contradict the findings regarding students attention to content found in the literature on open book testing. The research reviewed (Kalish, 1958; Krarup *et al.*, 1974; Weber *et al.*, 1983; Boniface, 1985) consistently found that students facing an open book testing situation spent less time studying the content to be tested than students in a closed book testing situation. In this study there was no significant difference between the attention time for the LACRO (M = 47.49 min.) and the OACRO (M = 54.96 min.) groups. One possible explanation is that when students use CAI, they become absorbed by the methodical process of going through the instruction. Also, students are usually in an environment conducive to study (i.e., computer lab, or learning center) whereas, studying text allows the student to quickly skim material or not read the content. Unless students make a conscious effort to put themselves in an environment conducive for study the potential for innumerable distractions (i.e. TV, radio, other people) exists.

Acquisition rate was not significant. This fact supports the conclusions drawn from the data on the posttest. The review option does not increase or decrease a student's ability to learn from the CAI. Since the review option does not hinder or help acquisition the designer must draw on other information to make a design choice.

These conclusions do little to address the highly vocal critics of CAI that regularly cite the linear function of many ICW programs as being limited or too simplistic to address the needs of learners (Bork, 1982; Pogrow, 1988; Streibel, 1986). Instead of concluding that the present study has failed to meet the demands of the critics, I would suggest that the critics are overstating their case. It may be that learners do not employ their entire repertoire of cognitive skills in every learning situation. The result is that for certain content or learning situations a linear approach may be the optimum way to communicate the instruction to the student; other studies suggest that such is the case (Hilgard, Atkinson & Atkinson, 1975).

Limitations

A partial explanation for the lack of significance in the results of this research can be explained by noted limitations. Six areas have been identified as potentially effecting the results of this study. These items include; length of the instruction, subject motivation, embedded and posttest question style, type of problem solving, learner characteristics, and student use of learner control.

The instruction used in the present study was much longer than the instruction used in similar studies. Subjects spent an average of 78 minutes in just the CAI portion of the treatment. This exceeds normally accepted standards for the amount of time, about 50 minutes, an adult learner is expected to maintain attention on content without a break. As a result, subjects demonstrated signs of fatigue (i.e., poor posture, yawning) during the experiment which could have had an adverse effect on learning. This effect however, should have been consistent across the treatments since the amount of instruction was the same for both groups.

Since there were no external incentives used in the experiment, motivation to master the content was determined by the subject's internal desire to learn map reading. This may have adversely effected learning, or the use of review, as indicated in the following posttest question: "What changes in training conditions do you believe would cause you to use the review more often?". The result was that 61% (43/70 S's) of the subjects indicated that establishing a required minimum score would have caused them to use the content review option more often, with another 21% (15/70 S's) indicating that a required period of time (that exceeds the actual amount of time to complete the instruction) for studying the instruction would cause more extensive use of the CRO. Therefore, it seems reasonable to assume that motivation had an effect on the use of review, which may have ultimately had an effect on achievement.

The use of multiple choice questions was also a limiting factor which may have adversely effected the use of review. Multiple choice questions do not require pure recall by the subject since the possible answers provide cues that aid recall. Also, the subjects admitted to a willingness to guess at the correct answer, before using the review, since there was no penalty for an incorrect response to a question. Most of the subjects in the OACRO group (74%, 26/35 S's) indicated on the post-treatment questionnaire that the use of fill-in-the-blank, or short answer questions would probably have caused them to use the review more often.

Another limiting factor that may have affected the use of review was the type of problem solving presented in the ICW. Specifically, problem solving was limited to algorithms. This type of problem solving is a given procedure that will result in a successful solution when it is consistently followed (Ingram, 1988). Doing an intersection on a map is an example of algorithmic problem solving. Algorithmic problem solving is on the low end of a continuum with heuristics representing the opposite end. A heuristic is a general strategy that can be used to approach a problem in such a way that it will not ensure success but will increase the probability of arriving at an acceptable solution. By their very nature heuristics are difficult to teach no matter what the method (Ingram, 1988). This is because they can involve the use of complex constructs and higher order rules with inconsistent applications (i.e., rules of spelling for English).

Because all soldiers, regardless of ability, are expected to be able to use a military map, the algorithms used in the map reading ICW must be clearly explained. Therefore, the algorithms involved were limited in complexity and applied in precisely defined situations. This made the problems in the map reading ICW comparatively easy to understand and solve given the quality of the instruction along with the high ability level of the subjects. The result is that the review was merely a tool to aid recall instead of being used to clarify concepts. This is highlighted by 89% (31/35 S's) of the subjects that reported on the post-treatment questionnaire (Question 5) that they primarily used the review to look up answers for the fact and procedure type of questions.

As alluded to above, ability level may have also been a factor. Other studies (Schaffer & Hannafin, 1986; Kinzie, 1987) have found that segregating the sample by measured learner characteristics had an effect on the data collected. Since the subjects were not broken down by ability level for the present research this issue can not be addressed. It is quite possible that by expanding the present research to distinguish subjects that represent the enlisted population in the Army, which have inconsistent educational backgrounds, a significant effect may have been achieved. Therefore, using the same content and design factors an aptitude-treatment interaction may reveal effects that were not found in the present study.

The last limitation falls in the area of student use of learner control. While it was noted in the post-treatment questionnaire that over 95% of the subjects were aware that the option to review the course content there is no indication that the subjects knew how to incorporate the review option into their study habits. Therefore, it must be assumed that the subjects knew how to make the best use of the learner control afforded them in this study. Clark (1982) reviewed a number of studies and has suggested that by mistake students choose methods of study that inadvertently result in less learning. In other words, merely providing someone a tool to do a job is no guarantee that they will know how to properly use the tool. Clark's review taints the aforementioned assumption and renders it tenuous at best.

Recommendations

Lack of significance in four of five stated hypotheses could lead to the conclusion that the use of review does not make a difference in a student's ability to achieve. Further, providing a review option may use the student's time to no apparent advantage. Such assumptions, however, should be tempered by previously mentioned limitations and an understanding that parallel access to information is a recently developed feature available in ICW. As learners become more familiar with learner control mechanisms, then the effects of these mechanisms (under different conditions) may become apparent. With this in mind, the following recommendations are offered:

First, the length of time a student must devote to the CAI, in one sitting, should be limited to generally accepted practices for more traditional forms of instruction (i.e., a 10 minute break every 50 minutes), so that fatigue does not act as an confounding variable. This can easily be accommodated by the computer software so that subjects can continue instruction from where they left off. Considering the effects computer monitors have on the eyes, and considering that text presented on monitors impairs reading efficiency, there is reason to study how these factors affect attention.

Second, the presence of external motivators should be examined as an independent variable with the use of review since the post-treatment questionnaire indicated that subjects would be more inclined to use the review if external motivators (i.e., minimum score) were applied.

Third, further research in this area should avoid the use of multiple choice questions since this type of question does not adequately measure a students ability to recall information, or demonstrate understanding of higher order rule using. If the embedded questions are designed to use more sophisticated question styles then an increase in programming complexity will be needed. Again, the results taken from the post-treatment questionnaire suggests that changing this part of the research would cause an increase in the use of the review. The unanswered question is; "Would an increase in the use of the review cause an increase in student achievement?"

Fourth, since the content of the instruction used for the present research did not seem to break the threshold of effectiveness that a simple, linear ICW design provided; a modification should be made to the research design. An effort should be made to examine the effect a content review option has on a students ability to learn content that either has complex algorithms, or requires the application of heuristic problem solving techniques. It is possible that more complex content would tender results that support the use of a content review option.

Fifth, further research should be conducted taking into account learner characteristics. This proposed research could organize the subjects according to reading ability, verbal learners, non-verbal learners, or spatial ability to name a few. In light of the evidence from previous research that has examined learner characteristics as an independent variable this could prove to be a promising research tack to pursue since the best instructional method for one learner may not necessarily be the best instructional method for another.

Sixth, research should be undertaken that examines the effectiveness of training subjects how to use learner control. As ICW becomes more sophisticated student control will also increase. As a result of this increased control it may become necessary to teach students how to use the ICW to their advantage. Additionally, the development of consistent design features which are used to access and navigate through information may greatly enhance the effectiveness of learner control options. In order to best evaluate the effectiveness of these concepts this research may need to be conducted in a situation where learner characteristics are also controlled.

Last, further research should be conducted that examines the idea that, for different content domains, there may exist different, optimal design structures. If true, then instructional designers would gain a valuable tool to help make decisions that affect the use of resources needed for constructing ICW. The value of this is emphasized by instructional designers, in industry and the military, propensity to heavily weight efficiency as a design criterion. The present research being an excellent case in point. Considering that the LACRO group spent significantly less time (M = 74.02 min.) processing the CAI than the OACRO group (M = 83.38 min.) with no discernable difference in achievement then, from an instructional designers perspective, it makes little sense to expend the additional resources required in designing, installing, and evaluating the content review option. Therefore, having the ability to prescribe the combination of design factors that effectively communicate a certain topic to the student, enhances efficiency in the planning and development phases of the instructional design.

When you consider that the goal of professional trainers is to expeditiously and by least cost produce a person with the skills necessary to be able to function in an occupational area and that experience is still considered the best teacher then there is a strong argument for using modest courseware designs for certain topics. Unpretentious courseware design have proven effective in numerous cases and should be recognized for their elegance instead of being chided for not fulfilling the expectations of those that do not, on a day-to-day basis, deal with the complex issues of the training arena.

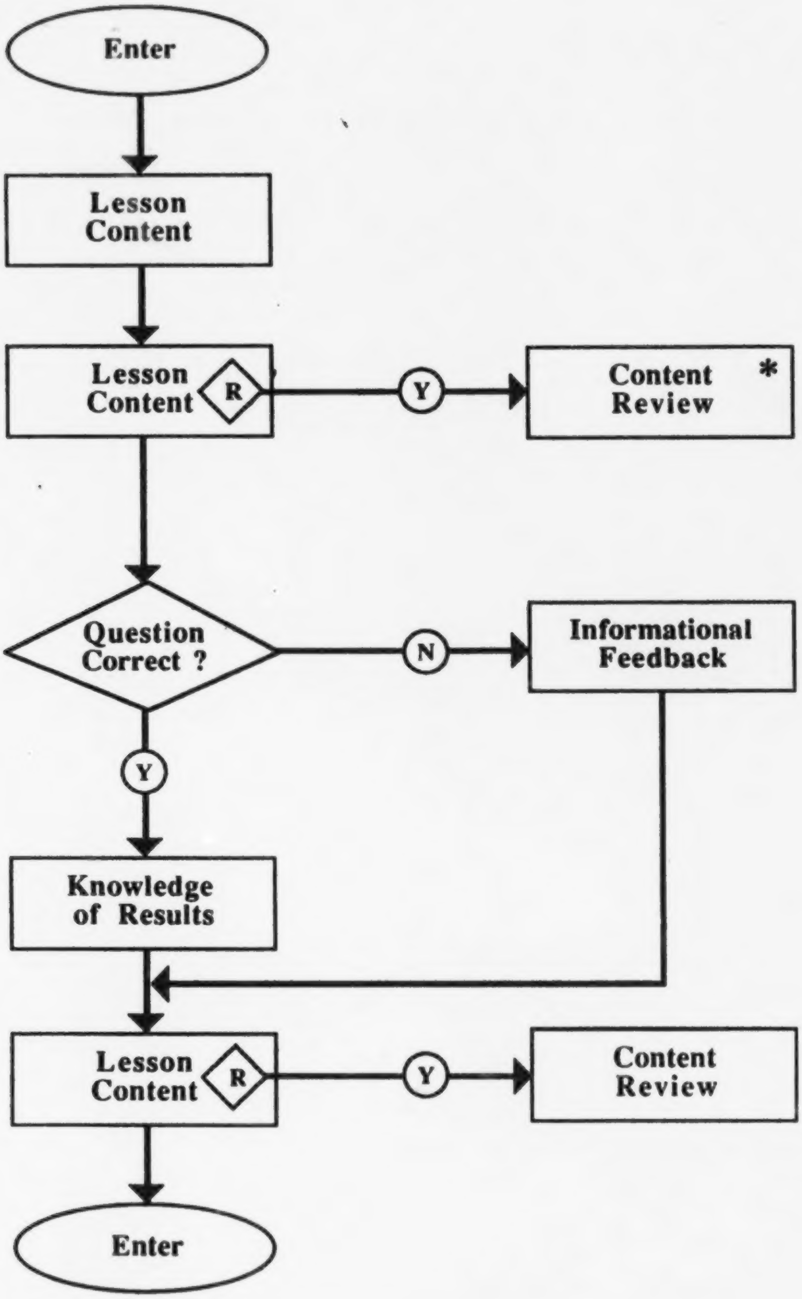
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Figure 1

Limited Access to the Content Review Option (LACRO)
(* After review student returns to point-of-access.)

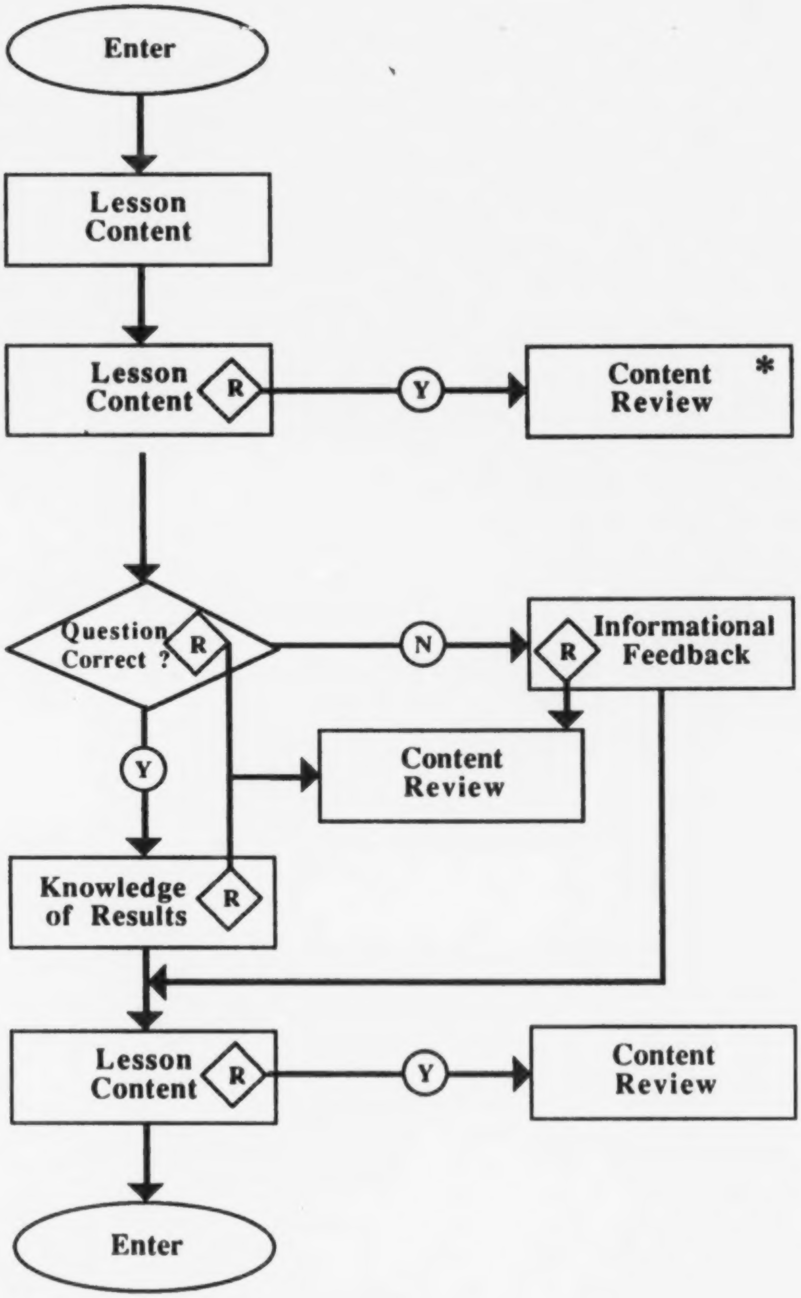
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Figure 2

Open Access to the Content Review Option (OACRO)
(* After review student returns to point-of-access.)

Table 1

Means, Standard Deviations, and Group Sizes Obtained for Total Posttest Scores

Group	n	Means	S.D.
LACRO	35	16.829	3.044
OACRO	35	15.914	2.832

Maximum score = 21.

Table 2

Summary Table of the Univariate Analysis of Variance Using the Posttest Total Score Data

Source of Variation	DF	Sum of Squares	Mean Squares	F Ratio
Group	1	14.629	14.629	1.693
Within Cells	68	587.714	8.643	

Table 3

Posttest Means, Standard Deviations, and Group Sizes Obtained for Fact, Procedure, and Problem Solving Achievement Scores

Question Type	Means	S.D.
	LACRO (n = 35)	
Fact	5.486	1.147
Procedure	5.971	1.043
Prob. Solving	5.429	1.632
	OACRO (n = 35)	
Fact	5.171	1.200
Procedure	5.714	1.126
Prob. Solving	5.229	1.505

Maximum score for each subscale = 7.

Table 4

Summary Table of the Univariate Analysis of Variance Using the Posttest Fact, Procedure, and Problem Solving Score Data

Source of Variation	DF	Sum of Squares	Mean Squares	F Ratio
		Fact Question		
Group	1	1.729	1.729	1.254
Within Cells	68	93.714	1.378	
		Procedure Question		
Group	1	1.157	1.157	.982
Within Cells	68	80.114	1.178	
		Problem Solving Question		
Group	1	2.800	2.800	1.240
Within Cells	68	153.543	2.258	

Table 5

Means, Standard Deviations, and Group Sizes Obtained for Acquisition Rate

Group	n	Means	S.D.
LACRO	35	.243	.085
OACRO	35	.206	.083

Table 6

Summary Table of the Analysis of Variance Using the Acquisition Rate Data

Source of Variation	DF	Sum of Squares	Mean Squares	F Ratio
Group	1	.025	.025	3.571
Within Cells	68	.483	.007	

Table 7

Means and Standard Deviations for LACRO and OACRO Lesson Times

Group	Means	S.D.
LACRO (n = 35)		
Lesson 1	3.475	2.053
Lesson 2	9.478	4.208
Lesson 3	4.995	2.199
Lesson 4	7.153	2.442
Lesson 5	8.825	2.977
Lesson 6	4.230	2.689
Lesson 7	3.834	2.918
Lesson 8	5.503	4.455
Lesson Total	47.491	18.248
OACRO (n = 35)		
Lesson 1	4.276	2.105
Lesson 2	10.939	4.106
Lesson 3	5.890	2.352
Lesson 4	7.543	2.619
Lesson 5	9.756	2.353
Lesson 6	5.171	2.087
Lesson 7	5.003	2.935
Lesson 8	6.380	4.262
Lesson Total	54.958	16.169

Table 8

Summary Table of the Univariate Analysis of Variance Using the Lesson Time Data

Source of Variation	DF	Sum of Squares	Mean Squares	F Ratio
Lesson 1				
Group	1	11.246	11.246	2.601
Within Cells	68	293.972	4.323	
Lesson 2				
Group	1	37.369	37.369	2.163
Within Cells	68	1175.056	17.280	
Lesson 3				
Group	1	14.033	14.033	2.708
Within Cells	68	352.374	5.182	
Lesson 4				
Group	1	2.673	2.673	.417
Within Cells	68	435.965	6.411	

(continued on next page)

Table 8 (cont.)

Lesson 5				
Group	1	15.162	15.162	2.106
Within Cells	68	489.671	7.201	
Lesson 6				
Group	1	15.490	15.490	2.674
Within Cells	68	393.955	5.793	
Lesson 7				
Group	1	23.904	23.904	2.792
Within Cells	68	582.265	8.563	
Lesson 8				
Group	1	13.478	13.478	.709
Within Cells	68	1292.599	19.009	
Lesson Total				
Group	1	975.724	975.724	3.283
Within Cells	68	20209.796	297.203	

Table 9

Means, Standard Deviations, and Group Sizes Obtained for Overall Time Using CAI (Course Time)

Group	n	Means	S.D.
LACRO	35	74.018	18.868
OACRO	35	83.375	18.850

Table 10

Summary Table of the Analysis of Variance Using the Course Time Data

Source of Variation	DF	Sum of Squares	Mean Squares	F Ratio
Group	1	1532.429	1532.429	4.309 *
Within Cells	68	24185.214	355.665	

* p = .042

Table 11

Summary Table of the Analysis of Covariance of Total Course Time and Review Time Data as the Covariate

Source of Variation	DF	Sum of Squares	Mean Squares	F Ratio
Group	1	275.748	275.748	.770
Review Time	1	183.041	183.041	.511
Within Cells	67	24002.172	358.241	

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Title:

A Research Approach to the Identification, Clarification, and Definition of Visual Literacy and Related Concepts

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Roberts A. Braden

A Research Approach to the Identification, Clarification, and Definition of Visual Literacy and Related Concepts

Abstract

This paper presents a report of a multi-phase research project which was conducted to provide a comprehensive description of visual literacy, its constructs and components. The Delphi technique was employed to elicit information and opinions from a panel of visual literacy experts. A set of statements based upon the initial input of that group was further refined by the group through successive Delphi iterations. While the Delphi process was central to this research, basic Delphi techniques were expanded to include an extensive instrumentation phase and a validation of the results of the Delphi study through a readministration of the instrument with a different group of subjects. A brief discussion of the background of visual literacy and a description of the Delphi methods used are included, followed by a report of the procedures employed in this project and the results of the study.

A Research Approach to the Identification, Clarification, and Definition of Visual Literacy and Related Concepts

Introduction

Visual literacy is a familiar term to the majority of individuals in the fields of education and educational technology. However, the term may mean far different things to different individuals. For more than two decades the charm of visual literacy as a general notion has exceeded its popularity as a defined (ill defined?) entity. Is visual literacy a set of skills? Is it a field of study, an academic discipline? Is it a metaphor, a misnomer, or just a mystery? These and many other questions regarding visual literacy have lacked definitive answers. This paper presents a report of a multi-phase research project which was undertaken to address some of the questions surrounding visual literacy.

Origins of Visual Literacy

In 1969 the first visual literacy conference was held at Rochester, New York. John Debes was the driving force behind that meeting and his seminal paper, "The Loom of Visual Literacy" (Debes, 1970), set the visual literacy movement in motion. The idea of visuals as a language was recorded in an Eastman Kodak publication in 1971. Visual thinking was advanced as a related concept the next year (Arnheim, 1972). And the following year Donis Dondis' classic text, *A Primer of Visual Literacy*, appeared (Dondis, 1973). By 1976 the term visual literacy (VL) had become a buzzword. In August of 1976 the theme of the twenty-second Lake Okoboji Educational Media Leadership Conference was "Visual Literacy -- The Last Word" (Cureton & Cochran, 1976). But it wasn't the last word. Although the Okoboji participants stated that "Before research can begin, a common definition of the term 'visual literacy' should be developed". (p. 99), no widely accepted (thus common) definition resulted from that conference.

Attempts at Definition

Debes himself initiated the ongoing definitional troubles. He wrote that "When I say 'visual literacy,' what I have in mind is a great dim shape, the outlines of which and the importance of which are not yet clear" (1970, p. 1). Debes agreed to write the first definition of VL with the caveat that the definition was tentative and "sure to be changed" (1970, p. 14). Dondis may have reinforced the general reluctance to create a sharply focused **common** definition when she advised, "One of the major pitfalls in developing an approach to visual literacy is trying to overdefine it (1972, p 9)."

Since those early days, the definitions of VL have varied widely. Some of the more recent definitions include only a narrow range of elements while others contain many. Some writers and practitioners have addressed only understanding visuals, others have included understanding and creating visuals, while still others have included a much broader range of abilities. Hortin, for instance, stated that VL includes the abilities required to "learn, understand, think, communicate and store information in one's mind visually" (1980, p. 21). In a definition deliberately structured to incorporate the essentials of visual thinking, visual learning, and visual language, Hortin and Braden offered this definition: "Visual literacy is the ability to understand and use images, including the ability to think, learn, and express oneself in terms of images" (1982, p. 169). As Baca and Braden noted, "even that definition fails to directly address design, creativity, and aesthetics as they apply to visualization." (1990, p. 100).

While the term *visual literacy* has endured, after those first few years the concept has gained few new advocates. There has been no disputing the fact that visuals can be used in communication. There has been no challenging of the basic premise that principles related to using and understanding visuals can be taught and learned. The inherent wholesomeness of VL remains, but not without challenge.

Criticisms

Over the years visual literacists have lauded the precepts of visual literacy, while others increasingly have asserted that VL is not a viable concept. The detractors have made an issue of rejecting VL entirely. Suhor and Little suggested that VL is "...not a coherent area of study but, at best, an ingenious orchestration of ideas" (1988, p. 470). Cassidy and Knowlton labelled visual literacy a "failed metaphor" and offered the proposition that "Visual Literacy (VL)--as a metaphor, as a concept, and as a movement--is a paradox. ...in the sense of [being] inherently contradictory". They asked "What is VL, or, by the criterion of a profitable science and technology, what might it become if it is to serve as an abundant generator of questions, hence a guide to fruitful research?" (1983, p. 67).

The aspects of VL which are most frequently criticized include its *theoretical foundations* and the *research* which has been conducted in the field. Hocking (1978) addressed the paucity of experimental research in the field thus:

> Much of the literature available fell within the realm of hypothesizing and undocumented personal opinion. ...Some research has been background research concerning the rationale behind Visual Literacy; and much of the field research has been without the tight control of experimental design. ...the tremendous amount of information published on a topic that crosses so many fields and disciplines prevents any hope of exhaustiveness... (pp. 10-11).

Clearly these and other criticisms relate to the expansiveness of VL and the failure of the field to clearly identify its components. Description and definition are at the root of many of the objections to VL. A comprehensive description of the components of visual literacy and of the ideas related to it might provide some structure for research that would validate the field. Cassidy and Knowlton called for a description of visual literacy which could provide direction for future research. They stated that "...if from the VL arena someone would step forward and offer conceptual and operational definitions of VL (no matter how incomplete and tentative), honest-to-goodness research work could begin" (1983, p 84). Spitzer and McNerny called for an operational definition of visual literacy, claiming that without one "...the nature of the construct is speculative, ambiguous, and too prone to misinterpretation" (1975, p. 31). Hocking stated that "The enumeration of the skills of Visual Literacy [would] help define the discipline" (p. 13).

Proliferation of "literacies"

First there was literacy. It had to do with the ability to read and write words. Then the concept was expanded to include aspects of being well read. When the term "visual literacy" was coined the conceptual door was thrown open. Other adjectives have been linked since to literacy, the most ubiquitous being "computer." Recently the term *media literacy* has been introduced -- and, as defined by Tyner (1989), that term would subsume VL.

As recently as the autumn of 1989 a call for papers for a London symposium contained the following opening paragraph:

> The term "literacy" is invoked by diverse groupings of academics, educationalists and media producers who want to see established concerns with print media extended to cover the fields of television, film, radio, video, audio, photography, graphic design and computer software. But do we all mean the same things by "literacy"? What is entailed, conceptually and politically, in extending its usage to all media forms? (IVLA, n.d.)

Proliferation of literacy terms only compounds the identity problems for VL. Yet the phenomenon has its lighter side. One of the participants in this research used the term *sexual literacy*, but no reference to it has been noted in the literature. (We can only hope that the latter term does not survive. How would we know what to classify as reading and what as writing?)

Many of the scholars who have addressed the theoretical foundations of VL have asserted that the basis for the concept of visual literacy has been derived by borrowing from a diversity of fields, including education, philosophy, perception, art theory, linguistics, and human developmental theory (Debes, 1970; Hocking, 1978; Hortin, 1980). In the process, however, VL has not [in the opinion of the present authors] created a substantial theory base or research identity of its own that commands academic respect.

Research Goals

The goals of this study were to identify the constructs of visual literacy, to determine the amount of agreement or disagreement which exists concerning the identified constructs, and to provide a measure of relative importance among the identified constructs. The following research questions were developed to enable these goals to be met.

1. What are the elements of visual literacy?

2. How much agreement exists concerning the identification of the constructs which are elements of visual literacy?

3. Given the constructs identified as elements of visual literacy, how important is each construct considered to be by persons active in the visual literacy field?

The Delphi Method

The Delphi technique is a research method which is used to elicit the input of a group of individuals and to pool their collective knowledge in order to formulate a group judgment or statement of opinion. The process is designed to maximize human intellect while attempting to minimize interpersonal dynamics. A major anticipated effect of the procedure is to generate a better estimate or a more sharply-focused opinion than can be expected from a single individual or from a group dominated by and individual.

Original Purpose

The Delphi technique was originally used for forecasting future developments. One notable example of such an application was the use of the method by the United States military for long-term threat assessment (Dalkey, 1969). When the Rand Corporation first conducted studies for the Department of Defense, they also conducted extensive tests to validate the methodology and reported these tests in a series of reports (Dalkey, 1969; Brown, Cochran & Dalkey, 1969; Dalkey, Brown & Cochran, 1969; Dalkey, Brown & Cochran, 1970).

The validation studies performed by the Rand Corporation utilized "almanac type" (factual) questions with identifiable "correct" (quantitative) answers. The studies showed that, with reiteration, the group estimate (identified as the median of the responses) became more accurate. Further, the diversity of answers narrowed toward a greater degree of consensus or agreement (Dalkey, 1969, p. 20).

Other Uses

The Delphi technique is now commonly applied in situations in which there exists knowledgeable opinion rather than questions about hard information for which there are specific correct answers. Recently, the Delphi technique has been applied in fields such as management, education, and medicine. It is used as a decision making process in formulating policy statements, in forecasting future technological developments of technologies and their applications, in risk assessment, and in curriculum development. Not only is the technique being used in a growing number of settings, wherever used, the Delphi process tends to generate statements which are better accepted than those derived through direct forms of interaction (Dalkey, 1969, p. 17).

The Delphi technique is particularly useful when an attempt is being made to achieve one of the following purposes:

> ...(a) determining or developing a range of possible alternatives, (b) exploring or exposing underlying assumptions or information leading to various judgments, (c) seeking out information that may generate a consensus on the part of the group involved, or (d) correlating informed judgments on topics spanning several disciplines (Harrison, 1987, p. 278).

Thus, the Delphi technique appeared to have promise for resolving the issue of visual literacy. The techniques were assumed to be an appropriate method for correlating informed judgments and identifying (and perhaps generating) consensus among scholars who study visual literacy.

Procedure for this Study

In the research reported here, the Delphi technique was the primary method employed to develop a comprehensive description of visual literacy. However, this research project was expanded beyond the Delphi study to include two phases. Phase one began with the development of an instrument which could be used to poll the opinions of a group of experts who participated in a Delphi study. The reactive phase of the study followed, in which the participants rated the statements on the instrument. Phase two validated the results of the Delphi study by asking a different population to rate the items on the same instrument.

Phase I: The Delphi Study

The procedures for selecting participants and developing the instrument were somewhat more elaborate than those described by Isaac & Michael (1981, p. 114-115). Their five step procedure for conducting a Delphi study was followed, except the opinion-gathering step was terminated at two rounds when early consensus was reached.

Population. The Delphi technique is a method for pooling the opinions of a group of experts. Therefore, the selection of subjects who would participate in this study involved the identification of a group of persons who could be considered experts on the topic of visual literacy. This selection was accomplished in the following manner:

1. A list of names was compiled which included:
    a. all the people who had published one or more articles in *The Journal of Visual-Verbal Languaging* (*JVVL*) in the previous five years,
    b. the people who had published in the readings from International Visual Literacy Association (IVLA) annual conferences between 1984 and 1988, and
    c. the participants at the IVLA Symposium on Verbo Visual Literacy which was held in Stockholm, Sweden, in 1987.

2. This list, which included two hundred seventeen names, was sent to the eight members of the 1988 Executive Board of the International Visual Literacy Association. Each member was asked to select from the list and to add other names in order to identify thirty persons whom they felt were knowledgeable about visual literacy or had made significant contributions to the field and could be considered "experts". A total of eighty-eight people were identified as having a degree of expertise adequate to be asked to participate in the Delphi study.

An invitation to participate in the Delphi study was sent to each of the eighty-eight people identified in this manner. The letter of invitation included a brief discussion of the Delphi technique and emphasized that a Delphi study is a long process for both the researcher and the participants. The recipients of this letter were asked whether or not they were able and willing to commit the time which would be required to complete the study. Of the eighty-eight invitations which were sent, seventy-three responses were received; fifty-nine of those responses were from people who agreed to participate in the study.

Instrumentation. A review of the literature was conducted to identify questions, concerns, and ideas which had been addressed as aspects of visual literacy. Based upon this literature review, twenty-six broad questions were formulated. These questions were to be used as stimuli for the respondents' statements of opinion regarding visual literacy constructs. A final question was added which asked the participants to identify areas of concern which were not addressed by the stimulus questions. This final question and the unstructured format for the responses were utilized in order to take this study beyond the limits of the existing literature and to benefit fully from the expert knowledge and opinions of the Delphi participants.

The participants were asked to respond to the questions with written answers. This diverges somewhat from the procedure usually employed in a Delphi study. It is more common for the researcher to formulate a tentative list of statements, thus making analysis of the responses much more manageable. In this case, providing such a list might have limited the ideas and constructs addressed by the participants and was, therefore, judged not to be congruent with the goal of providing a comprehensive description of visual literacy. However, since the responses were to be written by each participant, asking busy professionals to respond to twenty-seven questions would have made unreasonable demands on their time. Therefore, the questions were divided and six sub-forms were created, each of which contained seven questions. Of those seven questions, five were asked of only some of the participants, while the two broadest questions were on each sub-form. These two questions, asked of every participant, were:

> Provide a definition of visual literacy which is acceptable to you. It may be your own, someone else's, or one which you have modified. Some elements you may wish to include are: abilities to..... with (elements)..... for (purposes)..... using (tools).....
>
> What other concerns, opinions, questions etc. regarding the nature and/or the limits of visual literacy would you like to see addressed in this study? You might consider things I have left out in regard to a definition of the term, visual literacy as a field, visual language, the practice of visual literacy, educational implications, and visual literacy research.

Each participant was sent the master list of all twenty-seven questions and a shorter form consisting of seven questions. Participants were asked to answer all the questions on their short form and as many from the master list as their time and interest allowed. The final question on each short form asked every participant to examine the master list in order to identify aspects of visual literacy which were not already being adequately addressed. In addition, an extensive list of terms which might serve as stimuli was included. This list included terms which could be identified in the literature as related to visual literacy. Round One of the Delphi study thus consisted of a master list of twenty-seven questions, one of six short forms which each included seven questions, a list of terms, and a cover letter. This was sent to the fifty-nine participants in May, 1989.

Fifty-four responses to the questionnaire used in Round One were received. Each statement (many of which were quite lengthy) was broken into individual concepts. More than 1,600 concepts were identified in the responses to Round One. Because of the large number of items which needed to be included, the form was organized by grouping portions of statements. An effort was made to preserve as much of the original language of the participants responses as possible. This form included broad areas (constructs) and as many supporting details as could be identified and organized into the framework provided by the constructs. When completed, the form contained four hundred ninety-one items. That number was far too many considering that the participants were volunteers who might be overpowered by the task of evaluating so many statements.

The concepts were collapsed once more, losing some but not all of the participants' original phrasing. The revised form was structured as a questionnaire with 186 items -- still more items than desired, but much better than the trial form. Items were listed as statements, each to be rated for agreement/disagreement on a four-point Likert-type scale. This final form was the opinion gathering instrument used in the next two Delphi rounds.

Data Collection

On the two iterations of the Delphi study which utilized this instrument, the participants were asked to rate each statement (or portion of a statement) on a scale from 1 to 4, indicating the extent to which they agreed that the statement identified or elaborated upon an element of visual literacy. The respondents were asked to use the following values for the scaled responses. A response of "4" indicated strong agreement ("agree strongly"), "3" indicated mild agreement ("agree somewhat"), "2" indicated mild disagreement ("disagree somewhat"), and "1" indicated strong disagreement ("disagree strongly"). In Round Two, participants were encouraged to make written comments or to suggest re-phrasing of statements.

Data Analysis Methods

The distinctive characteristics of a Delphi study are 1) no face to face interaction between participants during the study, and 2) reiteration with statistical feedback. The statistical feedback consists of a summary of the group's previous responses, provided by including the extremes of the interquartile range (Q_1 and Q_3) and, for each individual, his or her previous response to each item. Including the first and third quartiles on the next round of the Delphi study gives the participants information on the range of answers selected by the central fifty percent of the group (from Q_1 to Q_3). This information was added to each item for Round Three.

In addition to feedback, the Delphi procedure requires data for the determination of *level* of agreement and *degree* of agreement for every item considered. Consequently, a set of simple statistics was generated from the Round Two responses:

	Statistic	Purpose
Q_1	upper limit of the first quartile	feedback
Q_3	upper limit of the third quartile	feedback
IQR	the interquartile range	degree of consensus
M	mean rating	level of agreement

For Round Three the IQR and M were computed. Q_1 and Q_3 were available but were not utilized since the Delphi procedure was terminated prior to a fourth round.

On Round Three, the Delphi participants were asked to re-rate each statement, this time considering the group's response and their own response on the previous round. They were also given the opportunity to make comments about the items for which their rating fell outside the interquartile range. Forty-three responses to Round Three were completed and returned. The interquartile range and the mean for each item was computed from these responses.

A *t*-test was performed on the summed means of all the items on Round Two and the summed means of all the items on Round Three to determine whether a statistically significant change in the ratings had occurred. There was found to be no significant difference (t=1.81, df=91, p.=.074) between Round Two (M=632.58, n=50) and Round Three (M=657.33, n=43); therefore, the Delphi study was concluded. (Had the difference been significant, another round would have been administered.)

Phase II: Validation

Phase II of this research project utilized a different population and involved re-rating the visual literacy concepts identified by the Delphi population. There were two goals for this phase of the project. The first was to validate the Delphi study by asking another group to rate the items on the instrument. The second goal was to provide a measure of importance of the items which were accepted as constructs of visual literacy during the Delphi study.

Population. Since a major goal of Phase II was to validate the results of the Delphi study, it was important that the subjects involved in this phase be both concerned with and informed about visual literacy. Therefore, the members of IVLA (as of October, 1989) who had not participated in the Delphi study were used as the population. Questionnaires were sent to one hundred eighty people.

Instrumentation and data collection. The list of statements which was used in the Delphi study was used as the instrument for this phase of the study. Because one of the goals of Phase II was to validate the Delphi study, the items which had been rejected by the Delphi participants (those with a mean of less than 3.0 on Round Three) were included in this phase. The statements were still accompanied by a four point Likert-type scale, but this time the respondents were asked to rate each item as to how important they felt each item to be.

Data analysis methods. The responses to the instrument during the validation phase were compared with the final responses to the Delphi study to determine if there was a significant difference in the ratings of the items. A *t*-test was performed on the summed means of the responses to all the items to determine whether there was a significant difference in the responses to the instrument as a whole. In addition, a *t*-test was performed on each individual item, comparing the mean response of the Delphi participants with the mean response from the validation group.

An *F*-ratio was computed to determine if the variance in the responses to the instrument during the validation phase was significantly different from the variance in the responses to the instrument on both iterations of the Delphi study.

Results

Information Resulting from the Delphi Study

The results of the Delphi study provide two types of information for each item: 1) the degree of consensus, and 2) the level of acceptance. These results are based on the statistical analysis performed on the final round. The interquartile range on the final round was used as the measure of the degree of consensus concerning whether each item identifies a construct of visual literacy. The items may then either be ranked by degree of consensus or arranged into groups by degree of consensus. The level of acceptance was used to determine the inclusion or exclusion of an item in the final list of constructs which define the field of visual literacy.

The measure of the *degree of consensus* on an item is the interquartile range. The interquartile range is figured by subtracting Q_1 from Q_3, thus identifying the range of responses among the central 50% of respondents. The smaller the interquartile range, the greater the degree of consensus. The larger the interquartile range, the less the degree of consensus.

The measure of the *level of acceptance* for each item is the measurement of group rating of an item; either the median or the mean for each item may be used. A level at which each item is accepted as a construct of visual literacy was established for this study. Items meeting or exceeding that level were accepted as a construct of visual literacy. Items falling below that level were rejected as constructs of visual literacy. In this study, to be accepted an item must have achieved a mean of at least 2.98 to be accepted (an arbitrary criterion derived by calculation of the .05 alpha level of all means of the final round). Any item with a lower mean was considered to have been rejected by the Delphi panel.

The level of acceptance and the degree of consensus may be independent of one another. It is possible, for instance, for there to be an extremely high degree of consensus (interquartile range of .5) regarding an item which is rated low enough to be rejected (M=2.97 or lower). However, the correlation between the level of acceptance and the degree of consensus for this study was found to be quite high (*r*=.908).

Statistical Analysis of the Visual Literacy Delphi Study

Changes in Degree of Consensus. In order to determine whether or not there had been a significant convergence toward consensus as a result of the Delphi process, the variance on Round Two was compared with the variance on Round Three. A decrease in variance on Round Three would indicate a convergence toward consensus; such an observation could then be tested for statistical significance by computing an *F*-ratio.

An *F*-ratio was computed to determine if the variance in the responses to Round Two was significantly different from the variance in the responses to Round Three of the Delphi study. The difference in the variance for the instrument as a whole (all 186 items) was found to be statistically significant (*F*=2.33, df=49/42, p=.003) between Round Two (var=5868.94, n=50) and Round Three (var=2521.04, n=43). The decrease in the variance (computed by squaring the standard deviation) shows a significant move toward consensus.

Non-Statistical Results of the Delphi Study

While statistical feedback on each reiteration of a Delphi study is a vital component of the methodology, the results of such a study are not necessarily reported statistically. Frequently the statements are grouped and identified as those items upon which there exists high, medium, and low degrees of consensus. An alternative is to rank the statements in order of the degree of consensus.

For many researchers, the most exciting aspect of a study is the possibility of contributing to the resolution of the question which stimulated the study. The opportunity to address the questions "What does this mean?" and "So what?" is usually confined to the discussion in the section of the report which presents conclusions drawn from the study. However, it is important to keep in mind that the goal of a Delphi study is to create a statement based upon group opinion and that such a statement is the true "result" of a Delphi study.

Arbitrarily, the authors have chosen to limit discussion of specific VL constructs to the "top ten percent." The nineteen statements regarding visual literacy elements, concepts, or constructs for which there was the highest level of agreement and the nineteen statements about which there was the highest degree of consensus are correlated 1:1. Not only are the statements the same, the rank orders of agreement and degree of consensus are identical. Those nineteen statements are (in descending rank order):

1. Within the context of visual literacy, a *visual* which is *visible* may include iconic, pictorial representations.

2. Visual literacy refers to the use of visuals for the purposes of communication.

3. Within the context of visual literacy, a *visual* may be seen with the eyes (visible).

4. Within the context of visual literacy, a *visual* which is *visible* may include man-made objects.

5. Within the context of visual literacy, a *visual* which is *visible* may include natural objects.

6. Within the context of visual literacy, a *visual* which is *visible* may include events.

7. The processes humans engage in to practice visual literacy (use visuals for the above purposes) include responding to visuals.

8. Designing visuals includes using the elements of visual design such as color, line, form, shape, light.

9. Responding to visuals may be done mentally.

10. Using visuals in communication may provide a means of communicating other than verbally.

11. Using visuals in communication may enhance communication by combining visual and verbal elements.

12. Within the context of visual literacy, a *visual* which is *visible* may include actions.

13. Designing visuals includes applying the principles of composition such as balance, rhythm, repetition and unity.

14. Designing visuals includes using visual cues to indicate movement, passage of time, distance.

15. Perception of visuals includes attending to the visual stimuli.

16. The influences upon meaning may lie within the interactions among these elements [within the viewer, within the visual image, within the context of the presentation, within the context of sociological influences].

17. Visual literacy involves the affective domain in that attitudes and emotions can be evoked with visuals.

18. The *study of* visual literacy involves the relationship among the components of research, theory, and implementation.

19. Within the context of visual literacy, a *mental visual* includes pictorial images.

> [Note: The complete list of accepted statements is available to other researchers when requested directly from the authors.]

Results of the Validation Phase

Rating of entire instrument. A *t*-test was performed on the summed means of all the items on Round Three of the Delphi study and the summed means of all the items on the final administration of the instrument. The difference in the mean responses was found not to be statistically significant (t=1.40, df=71, p=.123) between the results of the Delphi study (M=657.33, n=43) and the final administration (M=629.37, n=30).

Rating of individual items. A t-test was performed on each individual item to identify those statements which were rated significantly differently by the two groups. There was found to be a significant difference in means on 35 of the statements. No significant difference was found in the mean rating of 151 items.

Consensus. An F-ratio was computed to determine if the variance in the responses on each iteration of the Delphi study was significantly different from the variance in the responses on the final administration of the instrument. The results were:

There was found to be no statistically significant difference (F=1.74, df=49/29, p=.085) in the variance among the responses to the first iteration of the Delphi instrument (var=5868.94,n=50) and the validation phase administration (var=10,219.59,n=30).

The differences in the variance for the instrument as a whole (all 186 items) was found not to be statistically significant (F=4.050, df=42/29, p<.0005) between the results of the final iteration of the Delphi study (var=2521.04,n=43) and the validation administration (var=10,219.59,n=30).

Conclusions

1. The Delphi technique proved to be an appropriate methodology for identifying visual literacy constructs. The 186 statements generated in the first round yielded 167 statements that survived the agreement level criterion.

2. The Delphi technique proved appropriate for bringing visual literacy experts to consensus regarding the elements, concepts and constructs of visual literacy. Given a set of statements from Round One, the participants significantly narrowed their degree of agreement when rating those statements in the next two rounds.

3. The very strong correlation between the level of agreement and the degree of consensus (r=.908) indicates that there is the most agreement on those constructs which are the most highly accepted.

4. The set of agreed-upon statements emanating from this study can be the basis for structuring a coherent theoretical base for visual literacy. No longer can the charge be made that there is no substance to visual literacy or that the emerging field of visual literacy has no conceptual foundations. If VL appears to lack these things, it is likely a reflection of an immature discipline rather than an unsubstantiated one. The constructs exist.

5. Notwithstanding statements to the contrary in the literature, there is a high level of agreement on most factors associated with visual literacy. The majority of participants agreed, strongly or moderately, with **all 186** statements generated by the first round of the study. Moreover, 167 statements were agreed upon at a statistically significant (p=.05) level. These exceptionally high agreement levels indicate that there is indeed much agreement about the constructs of visual literacy -- at least among that segment of the population who consider themselves knowledgeable about VL. The term "visual literacy" may forever be criticized by those who treat the words literally or who themselves want to impose a

definition. However, the term is widely understood and the meaning given to it is far more universal than the detractors imply.

The same is true regarding the makeup of visual literacy as a field. The elements, components, and theoretical constructs are agreed upon at a remarkably high level by those individuals recognized as visual literacy experts.

6. Phase II of the study generally validated the findings of Phase I. A second group of participants, using a different criterion for rating, supported (as important) the VL constructs identified by the Delphi group. The validation group ranked visual literacy statements similarly to the Delphi group for 151 of 186 items.

Summary

This study was initiated to examine the issue of apparent lack of agreement concerning what the critical components of visual literacy are. Contrary to the conclusion that could easily be drawn from a review of the existing literature, this study shows that, among the scholars who study visual literacy, there appears to be a great deal of agreement regarding its basic tenets.

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Title:

Facilitating Allied Health Students' Acquisition of Clinical Reasoning Skill

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Facilitating Allied Health Students' Acquisition of Clinical Reasoning Skill

ABSTRACT

This paper discussess two methods used to clarify patients' problems and develop treatment plans to resolve them. The traditional problem solving approach is presented as a means to introduce students to patient evaluation and treatment planning, while clinical reasoning is seen as a more expert way to approach this process. The incorporation of problem solving early in allied health curricula, followed by instruction and practice in clinical reasoning is recommended. An instructional model for facilitating students' acquisition of clinical reasoning skill is presented.

The enhancement of students' ability to "problem solve" has received much attention in recent allied health literature. Concurrently, in the medical education literature there is a discussion of the "clinical reasoning process," a process used to think through patients' problems and formulate treatment plans. Both problem solving and clinical reasoning have as their goal the determination of a patient's problem and the development of treatment plans to resolve the problem. The purpose of this paper is to compare these two methods of resolving patients' problems, and to suggest a method of instruction that will facilitate students' acquisition of more expert reasoning.

BACKGROUND

Problem Solving Approaches

The discussion of problem solving in the allied health professions has centered around teaching strategies to enhance students' ability in this area (Burnett & Pierson, 1988; Olsen, 1983; May & Newman, 1980; Jenkins, 1985; Slaughter, Brown, Garner & Peritt, 1989) Although each of these models for teaching problem solving vary slightly, essentially the approach provides students with evaluation results which they analyze, synthesize into problem lists, and develop treatment programs to address the patient's problems. If patients were actually treated in this manner the practitioner would perform a general evaluation on a patient noting all normal and abnormal findings without judgement until the data collection process is complete. The practitioner would then review the evaluation findings, synthesize the results, break major problems down into subproblems, formulate goals for treatment, and finally develop a treatment plan. Figure 1 shows the format of this type of clinical problem solving. Although most commonly reported in the literature on teaching problem solving, apparently this method of addressing patients' problems is not utilized by expert practitioners (Norman, 1988).

Clinical Reasoning

Norman has noted that the majority of problems that are addressed in clinical medicine are solved by means that do not fit this typical definition of a problem solving model (Norman, 1988). Instead, physicians use what has become known as a "clinical reasoning process" (CRP) in addressing their patients' problems. Barrows described CRP as involving the use of hypotheses to guide the evaluation process, with diagnostic questions or tests used to confirm or refute the hypotheses (Barrows & Peltovitch, 1987).

According to Barrows the hypothesis-test method of clinical reasoning involves generating a hypothesis (or preferably, multiple hypotheses) regarding the patient's problems early in the evaluation process. Early hypotheses may be fairly general, not strongly tied to a specific diagnosis or problem source. These initial hypotheses are then mentally rank ordered in terms of their plausibility. The most likely hypothesized cause is then investigated, either with further questioning of the patient or with specific evaluative tests. As more information is gathered through the evaluation the practitioner continually re-orders the hypotheses in terms of their plausibility, deletes some, and gradually develops a more clear understanding of the patient's problem(s). Throughout the evaluation process the practitioner may revert to a more general evaluation format to gather more information on problems that should not be overlooked, eventually returning to the hypothesis-test method as the process continues. Figure 2 depicts the hypothesis-test, clinical reasoning process in flow chart format.

While Barrow's work focused on the clinical reasoning processes utilized by physicians, evidence exists that similar reasoning processes are used by experienced physical therapists (Payton, 1985), and presumably other allied health practitioners.

A comparison of clinical reasoning and problem solving shows is that there are two schools of thought regarding how to address patients' problems. The first (what we term "problem solving" approach) involves the collection of all evaluative information without judgement, followed by an analysis of the data collected. Clinical reasoning, on the other hand, involves an analyze-as-you-go approach. The results of each evaluative question or test is immediately interpreted and integrated with previously collected information to guide the practitioner to the next test to be performed or question to be asked. On one level the differences between these two approaches to patients' problems appears to be simply a difference in the sequence of patient evaluations. Examined more closely, clinical reasoning can be seen as requiring more complex cognitive processing of patient information which can result in a more efficient and effective identification of the cause of the patient's problem.

Both the problem solving and clinical reasoning approach to patients problems have their advantages and disadvantages. Problem solving can be seen as a more structured approach, utilizing routine evaluation formats to collect information on patients. This method may be essential for persons with relatively little experience in a profession, as utilizing a structured approach leaves one less likely to "miss" key questions or tests. However, problem solving can also be more time consuming than clinical reasoning, and result in unnecessary evaluative procedures being performed. Clinical reasoning is a more expert-like way of approaching patient problems, which involves higher levels of cognitive processing of patient information, and more rapid and efficient determination of the patient's problem. One potential problem with using the clinical reasoning process to evaluate patients is that inexperienced practitioners (and students) may jump to conclusions about the patient's problem and forget or simply delete as unnecessary some key evaluative tests. However, as persons gain a more meaningful and broader understanding of pathologies and their appropriate treatments, and develop a repetoire of experience in their chosen field, it is less likely that such errors will occur.

The models for problem solving instruction advocate introducing the model early in the educational program (Burnett & Pierson, 1988; Olsen, 1983; May & Newman, 1980; Jenkins, 1985; Slaughter, Brown, Garner & Peritt, 1989). This inital instruction provides students with the structure needed to gain experience with patient evaluation and treatment planning. However, since one goal of allied health education is to produce competent clinicians, and apparently expert practitioners utilize a quite different approach to solving patient problems than that traditionally referred to as "problem solving," incorporation of the more complex reasoning process into existing allied health curricula seems advisable (Payton, 1985). Such instruction can be sequenced late in the educational program, after students have gained initial clinical experience using the problem solving approach. Instruction in the performance of the clinical reasoning process has the potential to accelerate learners' transitions from novice to expert clincian. The following describes a method of instruction in clinical reasoning that could be incorporated into educational programs, sequenced after students have gained experience with the more traditional problem solving approach.

INSTRUCTIONAL MODEL FOR CRP

While there have been several reports of teaching strategies for developing problem solving abilities, little has been written concerning the instructional strategies that will facilitate acquisition of clinical reasoning skill. Instruction in the clinical reasoning process is made more difficult because it does not involve a linear type of thought process, but rather uses an iterative approach to patient evaluation. Thus, instruction on this method of addressing patients' problems must convey the complexities of the clinical reasoning process while providing for practice of the skill, thereby enhancing students' ability to use the CRP in their patient care.

While the clinical reasoning process has been described as being distinctly different from traditional problem solving, it is not so different from the type of reasoning used when encountering everyday unknowns. Wright described "diagnostic induction" as being the kind of reasoning process that is basic to normal human functioning (Wright, 1989). This is a process by which, when confronted with a "problem" or question to which there is no blatantly apparent answer one generates multiple hypotheses which are ordered in terms of their relative plausability. The plausability rankings provide guidance on which "leads" to follow when searching for other relevant information which will help to clarify the question or problem under study.

A common example of diagnostic inductive thinking is the way one would approach the problem of a car that won't start. Neither a mechanic nor an average car owner would try to determine the car's problem by completely evaluating all of its systems followed by a sorting out of this evaluation's results to identify the problem. Instead, both the expert mechanic and the average car owner would make some guesses (or hypotheses) as to what was wrong with the vehicle, such as the car being out of gas, the battery being dead because the lights were left on, or some general problem with the ignition system. Based upon these hypotheses one would perform some limited tests to determine which one is the real problem (looking at the gas gauge, checking the light switch, etc), and generate some plan to fix the problem. Showing students how the CRP is similar to the way they already think about common problems by using an example such as this may help to orient them to the usefulness of a hypothesis-test method of evaluating patients.

To help students understand the differences between the CRP and problem solving approaches it may be helpful to explicitly point out these differences. Following this introduction to the CRP, examples of its use in clinical practice should be provided to the learners. Since the CRP is actually performed mentally, without any overt sign of the information processing which occurs, presenting examples of it's use takes the form of the instructor "thinking aloud," by talking students through the steps involved in clinical reasoning. When presenting examples of clinical reasoning, a hypothetical patient case may be presented to the learners, with very little detail provided at the outset. The instructor would then talk through the steps being used (i.e. the steps shown in Figure 2) by generating lists of hypotheses about the patient, rank ordering the possibilities according to their plausibility, deciding upon information needs, selecting appropriate tests, receiving test results, modifying hypotheses, and so on. This method of instruction, based upon social learning theory, is referred to as modeling of the desired behavior.

An option to having the instructor simply talk through the reasoning process on a hypothetical patient is to use a videotape of an actual patient evaluation, with the instructor narrating the thought processes used to progress through the evaluation. Interactive videos, which would allow selective branching to different segments of an evaluation, provide an excellent, though expensive, medium for depicting the clinical reasoning process in action. A less expensive alternative which still allows a greater touch of realism to this demonstration of CRP is the use of slides which depict the various evaluation steps, again narrated by the instructor.

In whatever medium the example is presented to the learners, the patient case study should be selected carefully. It should require all of the steps involved in CRP, yet be simple enough so as to avoid requiring a larger knowledge base than that possessed by the learners. One of the complexities of teaching the clinical reasoning process (or any of the problem solving approaches) is that the success of a student's reasoning is dependant upon prior knowledge upon which the reasoning is based. For example, one could not expect a student to demonstrate competent clinical reasoning when evaluating a patient with a head trauma if the student did not know the basics of neurology, and the necessary evaluation techniques. Therefore it is important that the examples and practice cases presented be based upon some clinical problem with which the learners are familiar.

Following this initial demonstration of clinical reasoning, students should be provided with opportunities to practice using the CRP on patient cases. Three levels of practice that can be used to promote acquisition of clinical reasoning skills include participative modelling, individual practice on case studies, and practice in clinical education settings.

Participative Modelling

In participative modelling the instructor presents a group of students with initial patient information and requests their input on potential causes of the patient's problem, ranking of the hypothesized causes, etc. Throughout this process the instructor may prompt students with questions, cueing them toward particular types of information that might be helpful in determining the patient's problem. In this way the students get immediate feedback about the use of CRP in a non-threatening, group environment. In participative modeling the instructor provides progressively less and less assistance in performing the desired skill, thus allowing learners to increase their competence and self-efficacy in using the newly learned skill. This type of practice can be used effectively in the early stages of learning a new skill.

Individual Practice

After students demonstrate an understanding of this "new" type of clinical reasoning they can progress to the second level of practice. Here the students should be provided with opportunities to practice and receive feedback on their own individual use of the process. Practice items for the clinical reasoning process should take the form of realistic patient case studies, much like those presented in the example. The type of case study to be used for practice of CRP should be designed so that practice closely parallels the use of the process in clinical settings. Thus, all information about a patient must not be provided to the learner at the outset. Instead, case studies should begin with a small amount of information about the patient, such as the type of information that would be obtained when a patient is asked "Why did you schedule an appointment?" Additional information about the case study patient should be provided to the learner only upon request, as this allows mimicking the question-answer format of patient interviews and the test-results format of objective testing. Thus, if a student fails to remember to "ask" a key question, or "order" a vital test the student fails to receive crucial information that may affect the diagnostic/treatment process.

Given the iterative format of clinical reasoning, the format of practice items provides some challenges to the instructor. While it may seem awkward, written case studies can be used to provide this type of practice case. For example, two students could work together, one as the practitioner, and the other as the patient, or information source. The practioner would receive initial information regarding the patient, and based upon this information, would list possible causes of the patient problem, and rank order these causes in terms of their probability. The student would then request additional information from the patient to confirm or refute the most probable cause of the problem. The type of information requested could be answers to questions, or objective test results. The second student provides the practitioner with only the information requested, eventually culminating in the practitioner's selection of the patient's "diagnosis" and formulation of a treatment plan.

This method of working through case studies is certainly feasible, but is dependant upon the ability of learners to work together in teams. Computer programs written to provide patient information only upon request could be used to allow individual student practice. Interactive videos programmed to provide information to the learners in the same manner could also present an effective and powerful method for practicing CRP, this time allowing the learners to practice observation skills that are not afforded by the written or non-video computer-based practice methods.

In addition to the format of practice items it is also important to consider the sequence in which they are presented to students. Easy to difficult sequencing is recommended so that learners may first practice on problems on which they have a relatively high probability of successfully completing, thus allowing them to practice a new skill in low stress situations. Easy cases might describe patients whose problem is easily identifiable, has a fairly obvious source, or is commonly seen in clinical settings. More difficult cases might include patients with multiple problems, or seemingly contradictory evaluation results. The use of divergent practice items is also recommended, to allow students to practice applying the CRP with different types of patient problems.

During this level of practice it is essential that students receive corrective feedback regarding the effectiveness of their clinical reasoning. Feedback from the instructor should concentrate not only on the outcomes of the learner's use of CRP (i.e. the identified patient problem and treatment plan), but also on the process itself, perhaps by pointing out specific steps on which the learner needs to focus. When using the CRP two types of errors can be made. First, students may use the CRP itself incorrectly, referred to as a process error. For example, when presented with initial patient information a student may "collect" data randomly, without using hypothesized causes of the patient's problem to guide the data collection process. This type of error might be identified by asking the student why they elected to "perform" a specific test, and what kind of information they hoped to gain from it.

The second type of error that can occur when using the CRP is making incorrect assumptions about the meaning of test results, or the symptoms exhibited by a patient with a certain problem. These errors can be classified as knowledge errors. Students working with this type of error might appear to be randomly collecting data on a patient, but actually be working with a deficient knowledge base, and thus be generating implausible hypotheses. This type of error requires identification of the student's incorrect assumptions, and perhaps referral to text books or other references for remedial work.

When providing feedback about students' clinical reasoning skill, it is important to remember that no two individuals can be expected to take the same paths through the reasoning process on any given patient. The CRP is individualistic in that many of the steps require judgements based upon prior knowledge and experience. For example, when presented with a patient with low back pain, one physical therapist may rank as the most probable hypothesized cause of the pain as being a generated from a disc. An equally competent therapist with different prior experiences may believe that the most probable cause is a muscle sprain, and still another might hypothesize facet involvement. From these diverse starting points each therapist will progress by asking questions and performing tests to confirm their own hypothesis, and eventually revising their hypothesis to keep it in line with the information gathered from the evaluation.

Since one can not expect two experts to follow the same paths in thinking through a patient's problem it is important that one does not expect all students to perform the reasoning in exactly the same manner. The important point is that students do not make critical errors in their clinical judgement, such as forgetting key tests that might differentiate one type of patient problem from another. To help students recognize how important it is both to consider all possible causes of a patient's problem, and to not jump to conclusions about the problem source early in the evaluation process, contrasting patient cases should be included in the practice of CRP. This involves the development of cases in which the patients have similar presenting symptoms which result from different causes. A physical therapy example of these type of cases would be to present students with a case of a patient with shoulder bursitis, and one with a cervical radiculopathy. Both patients could have similar (though not identical) histories of the onset of the problem, identical pain distributions, and very similar range of motion and muscle strength. However, a few key tests could be performed on such patients to differentiate between the two problems. Failing to perform the tests might result in the incorrect identification of the patient problem, and development of an inappropriate treatment plan.

Clinical Education Practice

The final level of practice of the clinical reasoning process should occur in the most realistic setting possible. Clinical education experiences are ideal forums for practice of clinical reasoning, for it is in the clinic that the process takes on real meaning for the students and their patients. Under the supervision of clinical preceptors students can further refine their clinical reasoning skills, and experience first hand the results of their reasoning. Following a student conducted patient evaluation the clinical preceptor can use in depth questioning of the student to determine why certain tests were or were not performed. This will assist the preceptor in understanding the student's clinical reasoning, and will help to identify weaknesses in process or knowledge that might lead to ineffective determination of the patient's problem. The preceptor might then suggest potential causes of the patient's problem that the student did not consider, and correct any faulty assumptions that the student might have made during the evaluation.

DISCUSSION

The reasoning process utilized by health professionals is a complex one, which requires integration of information from numerous sources. The clinical reasoning process presented here can be seen as distinctly different from traditional problem solving models. The model presented for CRP instruction is intended to clarify the clinical reasoning process itself, and to identify instructional strategies to assist students in acquiring this critical skill. Figure 3 depicts the steps described for instruction on clinical reasoning.

While practical for implementation in most allied health educational programs, this method for teaching the clinical reasoning process has not been subjected to testing with students to determine it's effectiveness in achieving the goal of acquisition of more expert-like CRP skills. One difficulty in testing any instructional method for clinical reasoning is the difficulty in measuring performance outcomes. The authors know of no tool which allows for assessment of students' ability to reason in clinical settings, save clinical preceptor's subjective assessment of student performance. A recent effort to determine the effectiveness of a clinical problem solving model through the use of a standard critical thinking scale was unsuccessful, perhaps not so much because of the ineffectiveness of the model, but because the testing instrument used might not be an effective measure of the problem solving used in allied health practice.[5] The identification of an effective evaluative instrument for measuring learners' clinical reasoning skill would be of great assistance in determining the value of any clinical reasoning instructional model.

As mentioned previously, the use of the clinical reasoning process is dependant upon the student's prior knowledge, and their ability to recall and integrate information from prior coursework that might assist in the CRP. Current work in instructional design related to schema theory may help to identify ways to design instruction so that this information is more easily retreivable for use in the clinical setting. One problem that we have observed in students beginning to evaluate patients in clinical settings is their inability to distinguish between relevant and irrelevant evaluation findings. Using the clinical reasoning process may help to reduce the amount of irrelevant information that students obtain from patient evaluations, as each test or question is related to their hypothesis regarding the cause of the patient's problem. Again, instructional strategies that will facilitate identification of relevant cues would be of assistance in preparing students for competent clinical practice.

Additional research into the area of clinical reasoning may be directed toward the identification of critical characteristics of case studies to be used in the practice of CRP. Investigation into the attributes of media through which CRP practice is provided may also provide guidance in the design of effective learning experiences in this area.

Another area of interest is the issue of sequencing clinical reasoning instruction. We have recommended introduction of "problem solving" early in the health care professionals' curricula as a means of providing learner motivation and initial structuring of knowledge for use in health care settings. This initial instruction would be followed by later instruction in the hypothesis-test method of CRP. The question of whether it is necessary or advisable to teach problem solving before hypothesis-test has not been tested empirically. Some learners may be able to generate sufficient numbers of hypotheses regarding patient problems early in the curriculum so that simple problems may be addressed through this more expert-like method. On the other hand, other learners may not be able to utilize the hypothesis-test method until they have completed extensive clinical experience in their chosen fields, and may not use this method until they have completed their formal schooling. Studies of individual differences in ability to generate and test hypotheses may provide insight into the optimal sequencing of CRP instruction (i.e. problem solving prior to the CRP; focusing solely on CRP, or using some other method not yet addressed) for individual learners.

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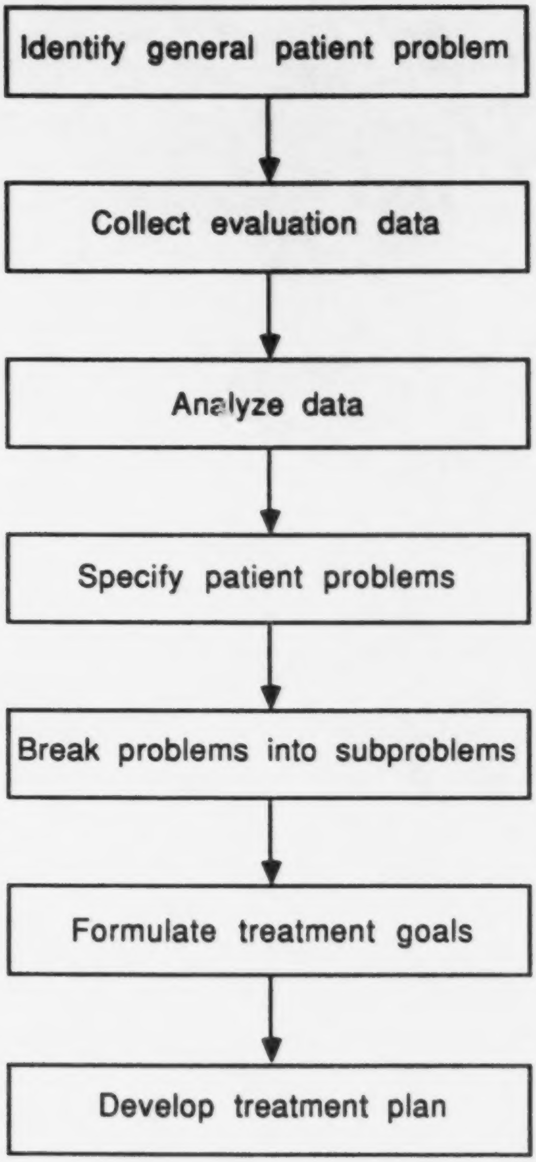
Identify general patient problem
Collect evaluation data
Analyze data
Specify patient problems
Break problems into subproblems
Formulate treatment goals
Develop treatment plan

Figure 1. The problem-solving process. Problem solving is presented as a linear process.

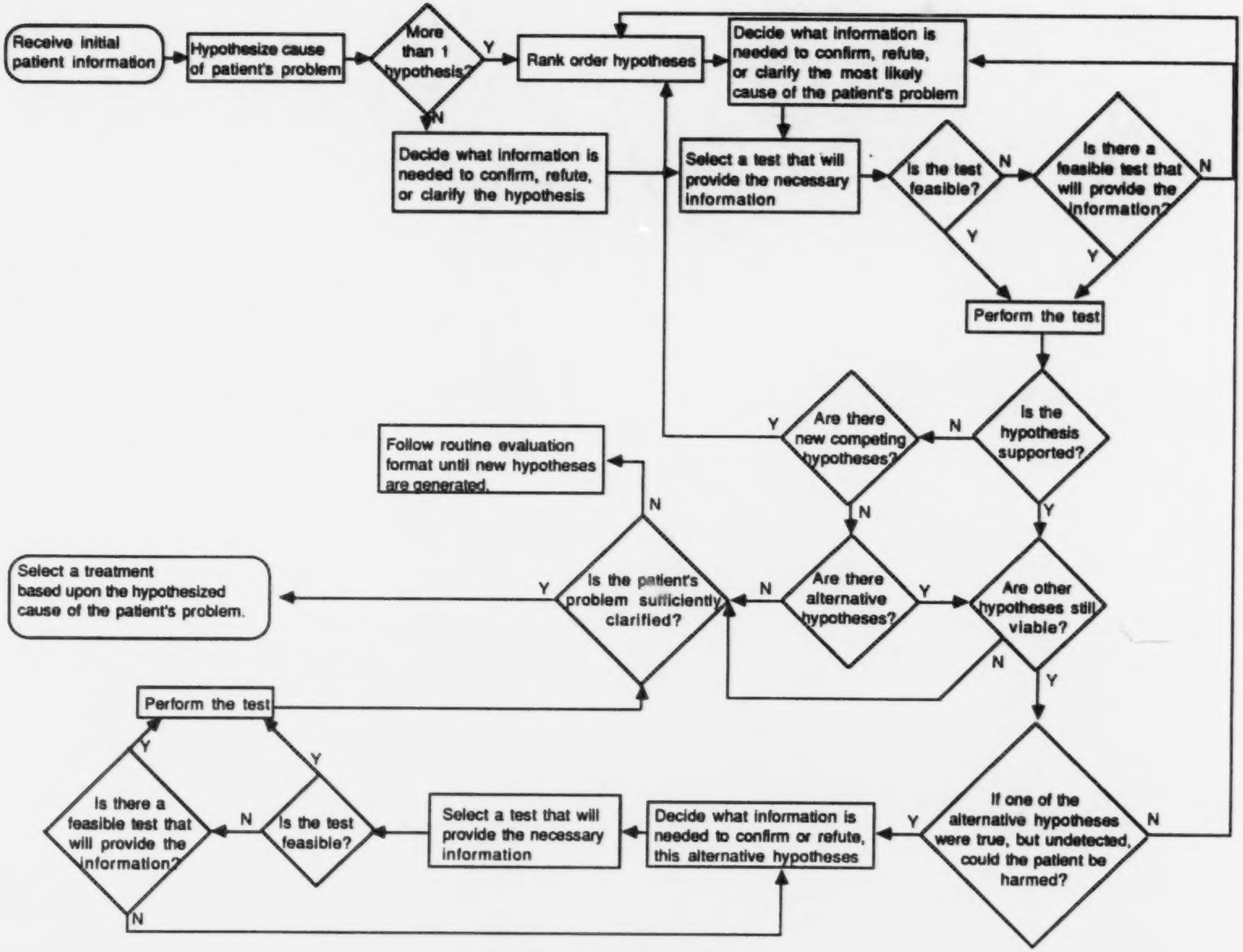
Receive initial patient information
Hypothesize cause of patient's problem
More than 1 hypothesis?
Y
N
Rank order hypotheses
Decide what information is needed to confirm, refute, or clarify the most likely cause of the patient's problem
Decide what information is needed to confirm, refute, or clarify the hypothesis
Select a test that will provide the necessary information
Is the test feasible?
N
Y
Is there a feasible test that will provide the information?
N
Y
Perform the test
Is the hypothesis supported?
N
Y
Are there new competing hypotheses?
Y
N
Follow routine evaluation format until new hypotheses are generated.
Is the patient's problem sufficiently clarified?
N
Y
Select a treatment based upon the hypothesized cause of the patient's problem.
Are there alternative hypotheses?
N
Y
Are other hypotheses still viable?
N
Y
If one of the alternative hypotheses were true, but undetected, could the patient be harmed?
Y
N
Decide what information is needed to confirm or refute, this alternative hypotheses
Select a test that will provide the necessary information
Is the test feasible?
N
Y
Is there a feasible test that will provide the information?
Y
N
Perform the test

Figure 2. The clinical reasoning process. Clinical reasoning is an iterative process in which information from each evaluative procedure affects the selection of the next procedure.

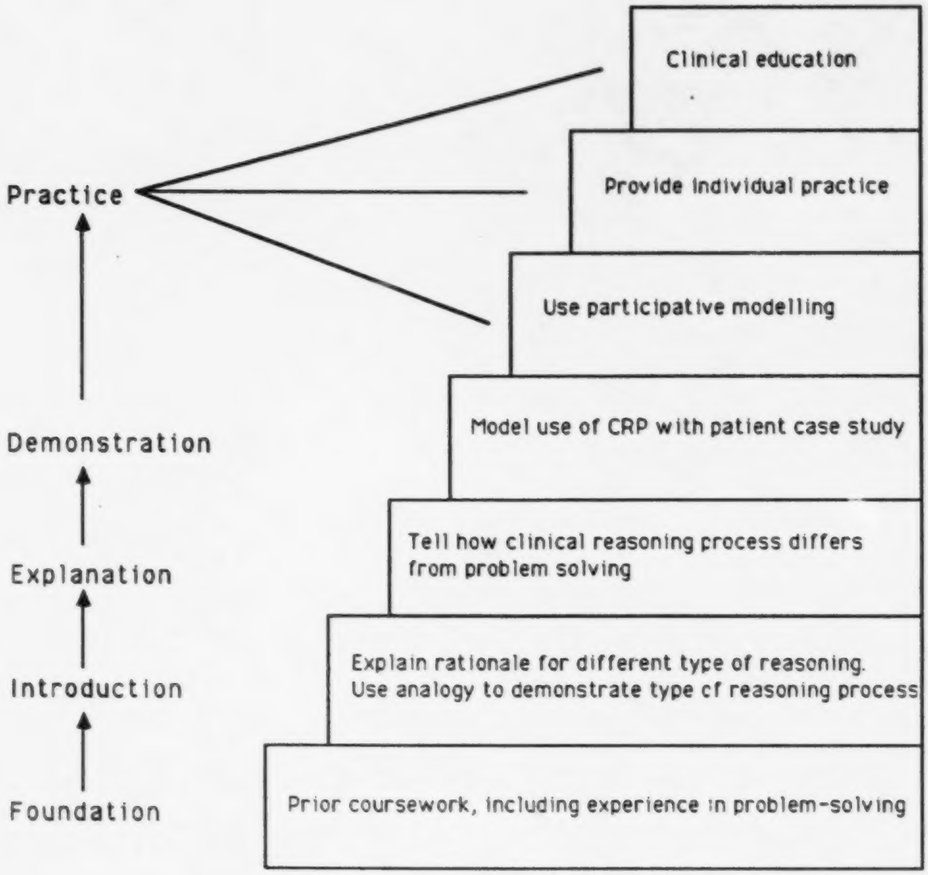
Clinical education
Provide individual practice
Practice
Use participative modelling
Model use of CRP with patient case study
Demonstration
Tell how clinical reasoning process differs from problem solving
Explanation
Explain rationale for different type of reasoning. Use analogy to demonstrate type of reasoning process
Introduction
Foundation
Prior coursework, including experience in problem-solving

Figure 3. A model for instruction in clinical reasoning. Note that this instruction builds upon a foundation of both coursework and prior experience with problem solving.

Title:

Cerebral Laterality in Color Information Processing

Author:

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CEREBRAL LATERALITY
IN
COLOR INFORMATION PROCESSING

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During the past several years, extensive research has addressed the interaction between hemispheric specialization and the processing of visual information. Studies suggest that visual material may be stored in memory in different locations or forms depending upon how meaningful the visual cues are in relation to the information presented. Other researchers have explored the degree of processing of visual information in the right and left cerebral hemispheres. Little research however, has investigated the specific interaction between how color information is processed and the relationship of that processing to hemispheric specialization.

The purpose, therefore, of this study was to investigate the interaction between hemispheric specialization and pictorial recognition memory for pictures presented in three different color modes: realistic color, non-realistic color and monochrome (black and white). A secondary purpose was to further confirm the efficacy of applying signal detection analysis to color recognition memory data as a means of obtaining a more accurate assessment of the role of color in visual information processing.

BACKGROUND RESEARCH

Substantial research has focused on the role of color in visualized instruction (Dwyer, 1972, 1978; Berry, 1974; Winn, 1976; Chute, 1979; Lamberski, 1980). This research represents one aspect of the larger theoretical debate which continues regarding visual complexity and human information processing. It has long been contended that the mere addition of visual cues will increase the ability of the viewer to store and retrieve visual information.. This orientation, termed "realism theory" by Dwyer (1967), has strong theoretical foundations (Dale, 1946; Morris, 1946; Carpenter, 1953 and Gibson, 1954) and is indeed the major premise of cue summation theory (Severin, 1967). Other researchers (Broadbent, 1958, 1965; and Travers, 1964) have, however, taken strong opposition to this theoretic base on the grounds that the human information processing system is of limited capacity and that, in times of rapid information reception, irrelevant cues may block the processing of other, relevant information. Studies (Kanner, 1968; Katzman and Nyenhuis, 1972; Dwyer, 1972, 1979) have investigated this apparent contradiction with conflicting results.

The inclusion or absence of color information can be regarded as one dimension of visual complexity. Color can function in a dual role when used in visual displays. First, it can serve primarily a coding function, providing additional information but not providing any realistic description of the display. In this case, the effectiveness of color can be predicted by cue summation theory, but not by the realism hypothesis. Alternately, color can be used to present a more realistic version of the visual display. In this instance, in addition to providing a greater number of overall cues, it provides the viewer with more realistic attributes or "handles" with which to store and retrieve information. When color is used in this fashion, its value could be predicted by the realism theories as well as by cue summation theory.

Much past research investigating the differences between color and monochrome visuals failed to take into account the fact that realistic color visuals contain intrinsically more information and consequently require more time for processing. In an attempt to resolve this methodological inconsistency as well as to more accurately assess the role of color in human information processing, Berry (1974) compared realistic and non-realistic color versions of the instructional materials on the human heart developed by Dwyer (1967). Data suggested that, in those learning tasks where visual materials contributed significantly to the improvement of instruction, realistic color materials were most effective. Later research (Berry, 1977, 1982, 1983) which investigated the color realism/complexity question relative to pictorial recognition memory found both realistic and non-realistic color materials superior to monochrome visuals. These findings suggest that cue summation theory may provide an accurate description of how color functions in basic information processing tasks such as picture recognition.

Other research by Berry (1984), in which the role of the cognitive style of field dependence identified by Witkin et al (1971) was investigated in relation to color information processing, suggested that field dependent individuals experience greater processing and storage difficulties. In this study, it was concluded that such difficulties may represent less efficient organization of the material in memory.

Studies by Craik and Lockhart (1972) and Craik and Tulving (1975) strongly suggest that a continuum of levels of information processing exists and that more meaningful information is processed more deeply and thereby is more effectively stored in memory. Such a theory would imply that realistic color materials, due to their greater number of meaningful cues would be more deeply processed and therefore more effectively stored. Paivio (1971, 1975) hypothesized a dual coding theory in which one system, the imagery system processes information related to concrete objects and events, while the second, verbal system processes language-based information. This theory may imply that more realistic information which might be easily described verbally could be processed separately from that which has fewer verbal/realistic labels. Much of this research suggests that visual information may indeed be processed in a variety of ways or in more than one memory location.

Extensive research during the past thirty years has addressed the concept of cerebral laterality and hemispheric specialization as another means of explaining variations in the processing of information. In summarizing this mass of research findings, Hellige (1980) presents the common conclusion that the right hemisphere of the brain specializes primarily in visuospatial processing and the left hemisphere focuses on verbal/linguistic tasks. While it would be absurdly simplistic to attribute the processing of specific types of information to one or the other hemispheres of the brain, it would not be unreasonable to expect visual information to be processed somewhat differently in the different locations. Although it is generally held that visual information is processed first in the right hemisphere, it is not clear how or where color information is processed. Beauvois and Saillant (1985) however, found significant data which indicated that color is represented in two separate memory systems, one verbal and one visual. When color is used in a realistic manner, it can supply additional, meaningful verbal or linguistic labels, while the use of color simply as a coding technique (non-realistic) may not be processed in the left hemisphere. Research by Meyer (1975), Daehler et al (1976) and Lamberski and Dwyer (1983) support the coding concept of color.

Research conducted on brain damaged subjects by De Renzi and Spinnler (1967) found that subjects with right hemisphere damage had significantly more problems in color naming and identification tasks while subjects with left hemisphere lesions did not demonstrate significant impairment. These results were further confirmed in studies by Scotti and Spinnler (1970), and Capitani, Scotti and Spinnler (1978). A study conducted by Davidoff (1976) with normally functioning subjects reported a right hemisphere advantage in sensitivity to perception of color stimuli. These findings were confirmed in a later study (Davidoff, 1977). Malone and Hannay (1978) however, investigated color memory relative to hemispheric asymmetry in normal subjects. Results indicated a significant main effect for color in the right visual field, implying a left hemisphere advantage. These results were, however, attributed to the use of verbalization in the performance task. Jorgenson,Davis, Opella & Angerstein (1980, 1981) found a right hemisphere advantage for color and a left hemisphere advantage for color/verbal responses.

From the preceding review, it is apparent that the means by which color information is processed is still, as Otto and Askov (1968) concluded, essentially unclear. It was the purpose therefore, of this study to investigate differences in the processing of color information within the two hemispheres of the brain. Since it is a well established fact that the two hemispheres do not function independently, it would be inappropriate to attribute specific modes of processing to one or the other discreet hemispheres. Consequently, in this study, comparisons were made between the processing attributable to the integrated functioning of both hemispheres as is normally the case, with processing accomplished by the right hemisphere independent of the left. To achieve this condition, it was necessary to occupy the left hemisphere with a complex verbal masking task, thereby effectively preventing it from effectively processing the presented visual information. Such a technique has become a commonly accepted means of localizing processing to the right hemisphere.

METHOD

The stimulus materials used in the study were similar to those used by Berry (1977, 1982, 1983, 1984) and El Gazzar (1984). These consisted of 120 stimulus slides and 60 distractor slides. All slides were obtained from a pool of geographic scenery slides taken by semi-professional and professional photographers in various locations of the United States and Canada. In selection of the materials, care was exercised to exclude all recognizable human figures, verbal materials or unique objects. The entire collection of materials was randomly divided into thirds. One third was retained as a realistic color group, a second third was recopied onto black and white slides and the remaining third was altered by photographic reversal to produce a non-realistic color group. By means of the photographic reversal process, the overall number of color cues could be held constant, while the degree of color realism could be manipulated.

The sample for the study consisted of twenty six graduate students drawn from academic areas of education, health professions and library science. All subjects were consenting volunteers.

The list learning procedure was employed, in which all subjects were first shown the set of 120 stimulus slides, individually for 500 ms each. On a random basis, subjects were instructed to perform a masking task while viewing either the first sixty slides or the second sixty slides. The remaining, alternate sixty slides were viewed without the performance of the masking task. The task employed required each subject to begin counting backward by threes from the number 488 as quickly as possible, while viewing the specified group of stimulus slides. In this way, right hemisphere processing could be localized by inhibiting left hemisphere processing. Subjects were subsequently presented with a random distribution of all slides (stimulus and distractor) for five seconds each. During that time, subjects responded on a checklist either "old" (stimulus slide - seen before) or "new" (distractor slide - never seen).

The design of the study was a two-way repeated measures type with three levels of the color factor (realistic, non-realistic, monochrome) and two levels of the cerebral localization factor (right specialized, integrated).

ANALYSIS

Analysis of the data obtained was conducted via the method of Signal Detection Analysis. This approach has been frequently applied to the analysis of recognition data in the past as a means whereby both recognition rate and error rate are taken into account.

Signal Detection Theory has been accepted as a reliable technique for assessing a subject's ability to describe the occurrence of discrete binary events. The basic model of SDT was described by Swets (1964) and has been used extensively to study the ability of individuals to distinguish the presence of a signal when that signal was mixed with noise. More recently, Grasha (1970) has suggested the use of SDT parameters in the study of memory processes. Signal Detection Theory has been applied specifically to recognition memory experiments involving pictorial material in research conducted by Snodgrass, Volvovitz and Walfish (1972), Loftus and Kallman (1979), Loftus, Greene and Smith (1980), Berry (1982, 1983, 1984) and El Gazzar (1984).

The mean probability of hits and the mean error rates for each treatment and level were calculated as well as the measure of sensitivity, d', which was determined from tables developed by Elliot (1964). To facilitate analysis, the d' statistic was uniformly transformed to eliminate negative values (d' adjusted). These data are presented in table 1.

TABLE 1
Means and standard deviations for hit and false alarm probabilities, error rates and d' by treatments and cerebral localization
(N = 26)

	P(H)		P(FA)		ERRORS		d' ADJUSTED	
TREATMENT	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Right localized								
Realistic Color	.480	.163	.519	.134	16.56	2.98	2.918	.431
Nonrealistic Color	.565	.193	.419	.176	13.07	3.34	3.427	.487
Black & White	.479	.184	.492	.136	14.12	3.32	2.909	.411
Integrated								
Realistic Color	.617	.174	.519	.134	13.87	3.24	3.283	.486
Nonrealistic Color	.533	.181	.419	.176	13.75	2.90	3.236	.555
Black & White	.546	..203	.492	.136	12.77	3.73	3.143	.579

Analysis of variance procedures for two factor repeated measures were conducted on the probability of hits (recognition scores), total error scores and on the adjusted SDT measure of sensitivity, d' adjusted.

With respect to the analysis of the hit probability data, a significant F value for the interaction, F (2,50) = 5.90, p = .0050 and a significant F value for the main effect of lateral localization, F (1,25) = 8.95, p = .0062 were obtained. The main effect for color was not significant F (2,50) =.62, p = .5422. Since a significant interaction was found, the Scheffe procedure for pairwise comparisons was applied. The results of that analysis is shown in table 2.

TABLE 2
Summary of pair-wise comparisons for hit probabilities, error rates and d' adjusted

HIT PROBABILITY	ERROR RATE	d' ADJUSTED
Real/Integrated > B &W/Right	Real/Right >Non-real/Right	Non-real/Right >Real/Right
Real/Integrated > Real/Right	Real/Right > Non-real/Integrated	Non-real/Right > B & W/Right
	Real/Right > B &W/Integrated	

Analysis of the error rates produced a significant interaction, F (2,50) = 5.84, p = 0053; a significant main effect for lateral localization, F (1,25) =8.51), p = .0074; and a significant main effect for color, F (2,50) = 3.80 p = .0291. Results of the pairwise comparisons are shown in table 2.

Analysis of the adjusted d' scores produced a significant interaction, F (2,50) = 8.18, p = .0008; a significant main effect for lateral localization, F (1,25) =4.55, p = .0428; and a significant main effect for color, F (2,50) =3.38, p = .0419. The results of the Scheffe procedure are summarized in table 2.

Since, in all cases, the interactions were significant, no further analyses of the main effects data were warranted. Each of the interactions is illustrated respectively in figures 1 through 3.

DISCUSSION

Examination of the hit probabilities indicate that under the right localized treatment, both the realistic and black & white treatments scored significantly lower than did the non-realistic color treatment. Additionally, the non-realistic group did not differ significantly from any of the treatment groups under the integrated treatment. This finding would suggest that the masking task inhibited recognition under the realistic and black & white treatments, but did not do so under the non-realistic treatment. An examination of the error rates confirms this, since both the realistic and black & white error rates are high, with the realistic color rate significantly so. It is because of this relationship between hit rates and error rates that the measure of recognition sensitivity, d' was derived. The statistic, d' accounts for both hit and false alarm rates and is therefore a more precise index of the true recognition rate.

Analysis of the d' scores also indicate that the non-realistic color group achieved significantly higher than did either of the other two color treatments under the right localized treatment. Additionally, the non-realistic color /right localized group did not differ significantly from any of

the integrated treatments, although the mean d' value for the non-realistic/right localized group was somewhat higher
(see figure 3).

Reasons for these findings can be drawn from the literature on cerebral asymmetry as well as from research on memory and information processing. The left cerebral hemisphere is generally attributed with processing verbal and linguistic information, while the right hemisphere tends to specialize in visuospatial processing. In the case of the images presented in this study, it could be concluded that the recognition process incorporates both types of processing, as research generally suggests. The right half processes the visuospatial component which includes color information, while the left hemisphere processes verbal or labeling information i.e. tree, lake, rocks etc. It is this combination which constitutes "realism", the visual image plus the verbal labels describing previously encountered concepts. In the case of the right localized groups, the verbal label component was inhibited by the verbal masking task, reducing the effectiveness of that form of processing. In the case of the non-realistic treatment, the additional color cues, which did not have any verbal or "realistic" associations were used purely as unique cues for storage and retrieval of the information. Since there were no realistic verbal cues, these were not used in the processing of the images. In the case of the integrated treatments, the findings of previous studies (Berry; 1977, 1982, 1983,1984) were upheld, in that realistic color materials are generally found to be superior to other color formats.

These conclusions are supported by the now classic work of Craik and Lockhart (1972) and Craik and Tulving (1975) which contends that more meaningful material is processed more deeply. In the case of visual material, the combination of imagery (color and structure) and semantic description (verbal labels) contribute to more complete or deeper processing. When part of this information is inhibited, the remaining information is processed less deeply. The lack of labels in the non-real group is replaced by more unique color codes which serve to process the information more deeply.

Research related to cerebral asymmetry also supports this finding. Beauvois and Saillant (1985) suggest that color information is stored separately, in both hemispheres. This would imply that if the left hemisphere processing of color information is inhibited, the processing would continue in the right. Research by Jorgenson, Davis, Opella and Angerstein (1980, 1981) also suggest left hemisphere color/verbal processing and right hemisphere color processing. This study inhibited the left hemisphere processing but permitted right hemisphere color processing to proceed. Realistic color, which is generally considered "color" in most research is the type of color information processed in the left half, since realism implies semantic or verbal labels. Right hemisphere color processing is non-verbal and thereby represents the type of processing done with non-realistic color.

The primary conclusion of this study, therefore, is that color processing is bi-locational, with realistic/verbal image processing being done in the left hemisphere and pure color processing being done in the right hemisphere. In terms of color realism, it can be concluded that visual realism probably constitutes a combination of information, some being imaginal and some being verbal in nature.

A word of caution should however be attached to the interpretation of these findings. This study utilized a verbal (arithmetic) masking task to occupy and therefore inhibit left hemisphere processing in the right localized treatment group. It cannot be completely assured that this task completely engaged the processing of the left half, but rather only interfered with such processing. It is the suggestion of this researcher that further research address these questions using perceptual rather than verbal means of localizing processing to either half of the brain to assure more complete localization of processing. Such presentation formats would present different stimulus materials, simultaneously to each individual visual field (left, right).

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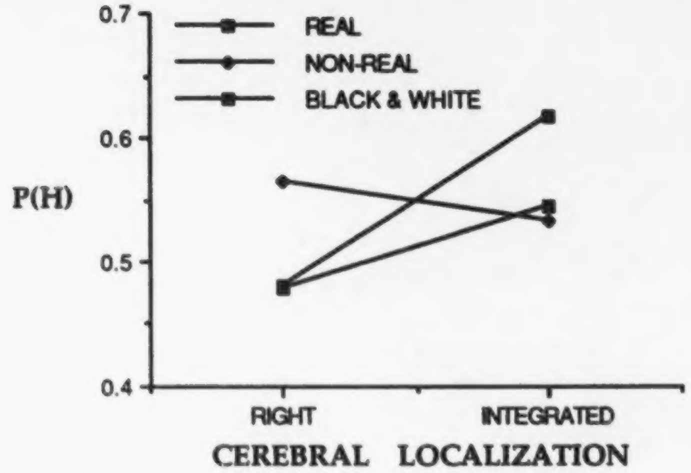

FIGURE 1
Hit probability - by - cerebral localization interaction for color treatments

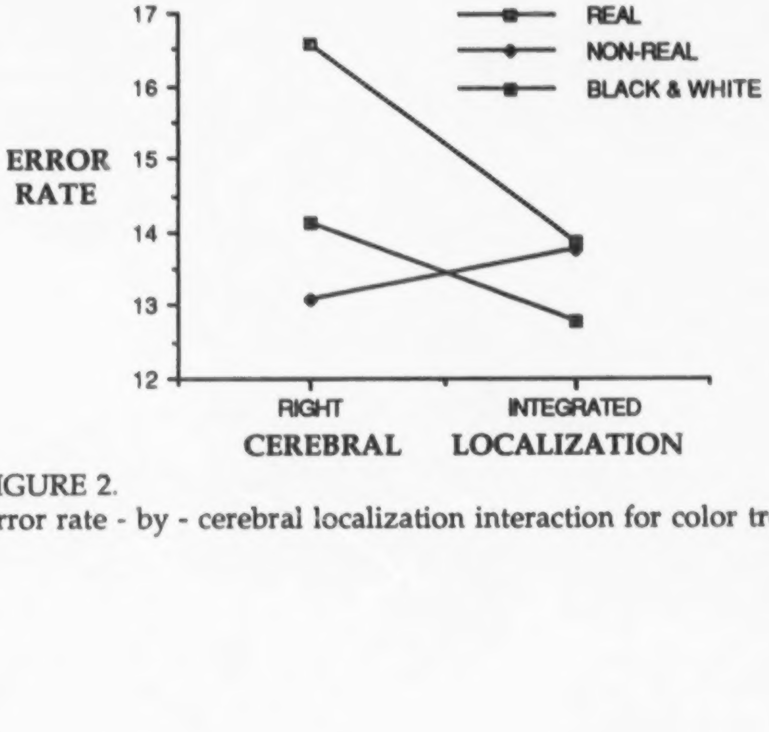

FIGURE 2.
Error rate - by - cerebral localization interaction for color treatments

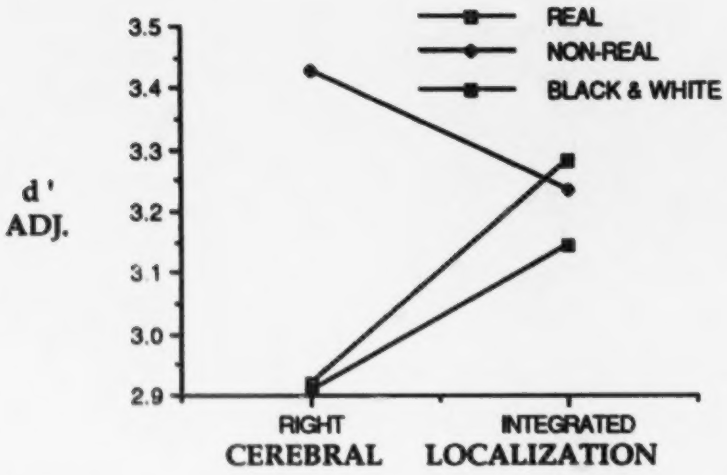

FIGURE 3.
d' adjusted - by - cerebral localization interaction for color treatments

Title:

Discretion vs. Valor:
The Development and Evaluation of a Simulation Game about Being a Believer in the Soviet Union

Author:

Barbara Blackstone

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DISCRETION VS. VALOR:
The Development and Evaluation of a Simulation Game about Being a Believer in the Soviet Union

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Abstract

Lenin's 1918 decree on "Separation of Church and State", updated in 1975, reaffirms atheism as the only official stance for Christians in the USSR. This is in spite of the 1000-1500 year histories of some of the established churches, and the registration as believers (Christians) of at least a fourth of its people. DISCRETION VS. VALOR gives players a chance to: identify with "believers" in the USSR in order to get new images of these persons; gain sympathethic understanding (empathy) for Christians in the dilemmas posed as they exercise their faith; be active participants in decision-making in a family group context. The 24 dilemmas requiring choices from players come from research in the USSR, from stories of recent emigres and frequent USSR travelers, and from American and British institutes which monitor the many legal and extra-legal discriminatory practices faced by believers. The game prototype was tested, evaluated and revised during ten field tests in 1987. During 1988 celebrations of the millennial year of Russian Orthodoxy, 72 North American Christians played the revised game in fifteen "family" groups, returning self-report evaluations which included 78 claims of "identification" with at least one of the game's characters. Reports of the game's greater-than-average influence upon their cognitive learning ("5" or above on a 7-point scale) came from 76% of the players, while 60% of all players reported that the game experience produced changes in their attitudinal affect. However, comparison of pre-and post-game measures of behavioral intention for six common religious practices showed 95% of players with altered "commitment levels" after play. Future tests of "identification theory" and "role empathy" are suggested by this study.

Introduction

In 1990, it is difficult for Americans to remember the "bad old days of the cold war" with the rapid changes that have taken place in Eastern Europe during the past year. Mass demonstrations, calls for independence within the Soviet Union itself, free exercise of election rights and the promise of multiple party elections from Soviet President Gorbachev testify to **glasnost** and **perestroika** in the political arena. There are even some signs of increased religious openness in this offically atheistic nation although church leaders are cautious in their pronouncements. London's Keston College and the American-based Institute for Religion and Democracy, watchdogs on all matters of religious freedom, report release of large numbers of previously held "prisoners of conscience". The return to the parishes of several hundred "non-working" Russian Orthodox churches, previously designated museums or public buildings, seems to demonstrate acknowledgment by the Councils on Religious Affairs that insistence on atheism as the only official belief has not succeeded in stamping out the latent faith of Soviet "believers" (the name used for all Christian groups in the USSR). January 8 media coverage of thousands of Russian Orthodox parish members openly celebrating Christmas, many for the first time since Lenin's 1918 decrees, gave credibility to a possible new era in church-state relations. Even the long fight by Ukranian Catholics for recognition as a separate denomination is given some hope for dialogue by Gorbachev (February 1, New York Times). Actual legal enactments are still lacking, so it remains to be seen if both legal and extra-legal long-standing societal discrimination will continue to be exerted against believers. Still, American Christians may see some hopeful signs for Soviet brethren.

This was not the case in 1986 when the present study was begun. Americans still had very limited information, and hence a curtailed view of persons and conditions in countries behind the "Iron Curtain". When the Fellowship on Reconciliation undertook to promote more understanding about ordinary Russian people, they entitled their photo series, "Forbidden Faces." Media coverage about persons in the Soviet Union, rather than helping Americans to form sympathetic or even accurate images, added to their misconceptions, when it pictured Russians as unfriendly enemies. The pre-summit characterization of the Soviet "evil empire" by the American President did little to alleviate natural antipathy caused by lack of information or even intentional build-up of distrust by the media.

Misconceptions were even stronger for American church members with the specter of atheism added to the overall negative attitudes. Soviet publications usually portrayed religious communities as being enfeebled and dominated by "old, superstitious **babushki**", suggesting the death of the church when these Russian grandmothers were gone. The more frequent criticism was that Russian Christians had so compromised the faith that it's authenticity was gone. Both American and Canadian press releases were critical of Soviet church representatives at Vancouver's 1983 World Council of Churches Assembly for neglecting to use the occasion to chastise their government's position on religion and human rights.

The former discrimination faced by Soviet Jewry and refusniks was harshest of all, but this subject received much more media attention and public outrage on this continent. By contrast, North American Christians, even those who might have been disposed to be sympathetic to their USSR counterparts, had little information about those persons whom the Soviet state branded as believers. Vague knowledge about Lenin's post-revolution decrees about atheism as the only officially endorsed position produced more prejudice than sympathetic understanding.

DISCRETION VS. VALOR was developed to address this need by supplementing other publications produced by the National Council of Churches' Friendship Press for its 1988 study of Peoples and Churches of the Soviet Union. In this year of the millennium of the Russian Orthodox Church, a stated goal called for a change in attitudes:

> ... to bring about a recognition of our prejudices, fears and distorted images, so that we (North American Christians) may be open to fresh insights about people and churches in the USSR.

A goal of "being open to fresh insights" suggested that some learning objectives for the 1988 Soviet study would involve attitudinal change. Designers and users of simulation games claim that this more experiential learning method makes gaming particularly effective in producing changes in attitudes. Four advantages claimed for simulation gaming include: potential for attitudinal change; the realism that comes from group interaction in decision-making; possible "identification" with persons whose roles are played (Williams, 1986) and role empathy (Livingston et. al., The Hopkins Games Program, 1973) or sympthetic understanding about those who are portrayed.

The purpose of this study was to develop and evaluate a simulation game involving participants' identification with and sympathetic understanding of those persons who are called "believers" (Christians) in the Soviet Union. Three learning objectives would guide the formative evaluation process; criterion-referenced summative evaluation would be conducted after revisions.

Methods of development and formative evaluation

In 1986, the author composed seven character roles and 28 decisions, called "commitment level" in the game, which typified Soviet believers' actions. In spring of 1987, a research grant provided opportunities to travel for several weeks to the USSR to interview believers in a variety of settings. Following these interviews, six characters were retained, roles were revised, playing rules were developed, and sets of cards were constructed to portray four levels of COMMITMENT and RISK that each of the Soviet characters might experience under present discriminatory regulations, both legal and extra-legal.

The research trip to the Soviet Union also afforded opportunities to secure visuals to supplement the game. A 42-slide set, Picture Yourself, A Soviet Believer, accompanies the game and acquaints the players with each other's decision choices.

Content review of game rules, cards, and roles by subject matter experts was done by five frequent Soviet travelers, defined as those whose work within agencies in the USA caused them to travel repeatedly to the USSR and to have extensive contacts with Soviet Christians. Included were Pittsburgh's Cultural Affairs Chairman of Peace Links, the head of the Chicago-based Institute for the Study of Marxism and Christianity, and the lone U.S. Protestant representative from the National Council of Churches to the USSR, in residence there from 1983-1986. The initial design review was done by Bailey and Tarasar (1987), the authors of the Friendship Press guidebook for this ecumenical study.

Throughout June and July of 1987, Field Trials of the game were conducted with populations of prospective teachers who were preparing to provide leadership for the 1988 millennial study. Two university classes, one in Games and Simulations and another in Intercultural Communication, participated in Field Trails of the game and provided suggestions for eight revisions of the game. A total of eleven Field Trails were conducted, involving 228 players on campuses in four eastern states. (Figure 1: Flowchart of Phase 2 & 3 Evaluation Processes)

Use of several types of assessment forms provided bases for evaluation of these instruments during the field tests. Two specialists, one in evaluation and one in test design, provided expert review of the instruments judged to have the greatest usefulness in formative evaluation. (See current forms in Appendix.)

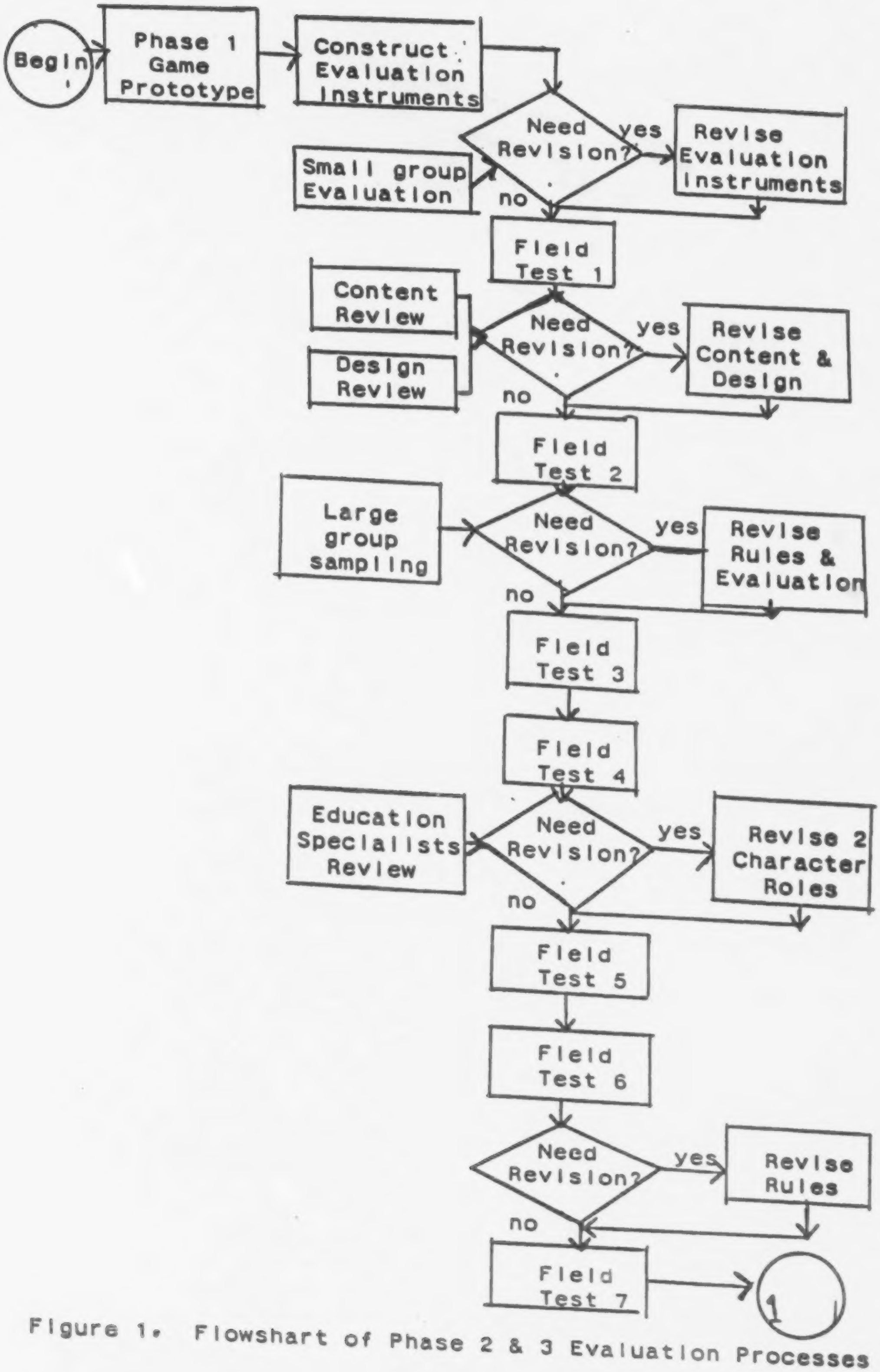
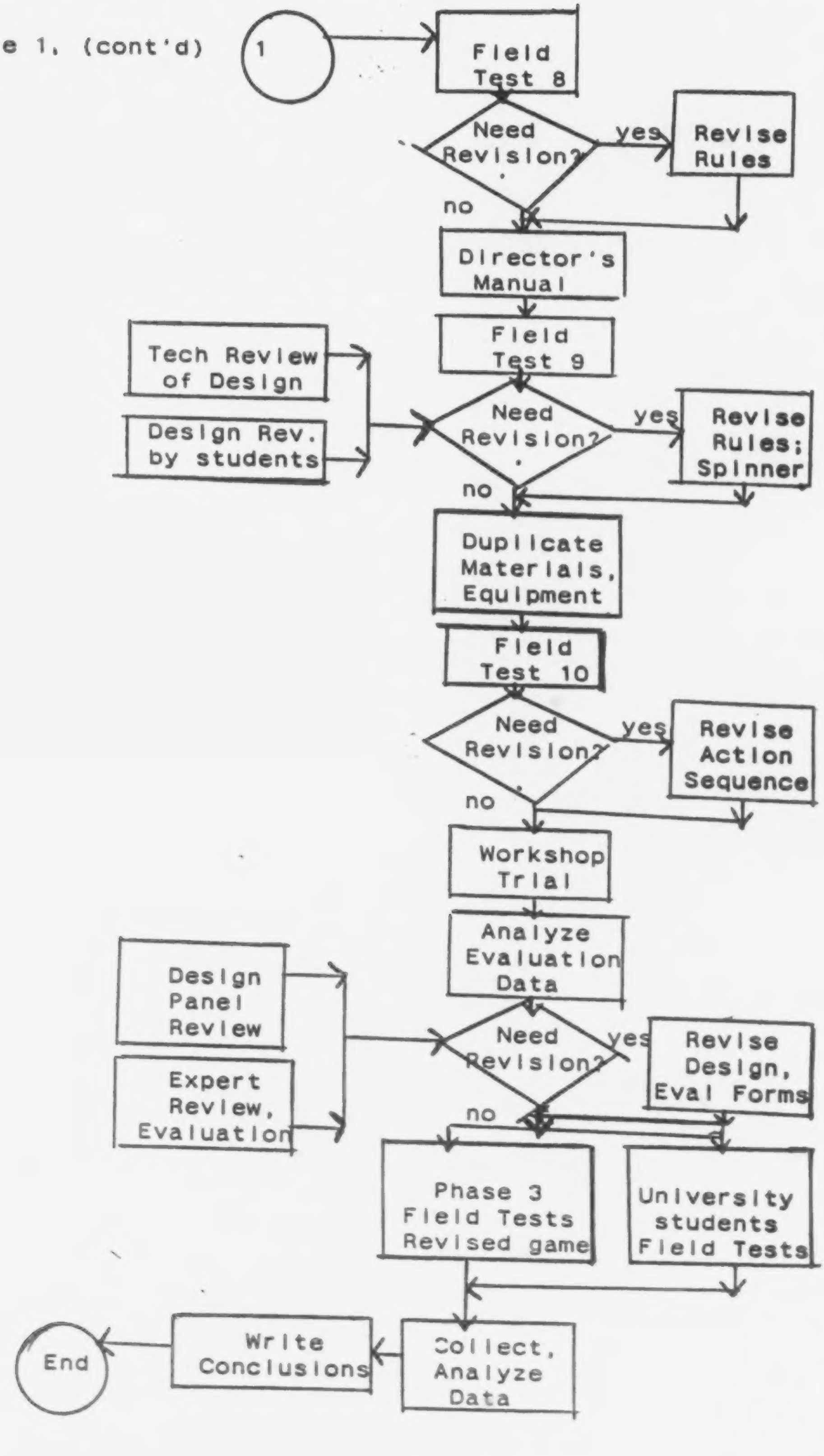

Begin
Phase 1 Game Prototype
Construct Evaluation Instruments
Need Revision?
yes
Revise Evaluation Instruments
Small group Evaluation
no
Field Test 1
Content Review
Design Review
Need Revision?
yes
Revise Content & Design
no
Field Test 2
Large group sampling
Need Revision?
yes
Revise Rules & Evaluation
no
Field Test 3
Field Test 4
Education Specialists Review
Need Revision?
yes
Revise 2 Character Roles
no
Field Test 5
Field Test 6
Need Revision?
yes
Revise Rules
no
Field Test 7
1

Figure 1. Flowshart of Phase 2 & 3 Evaluation Processes

Figure 1. (cont'd)


1
Field Test 8
Need Revision?
yes
Revise Rules
no
Director's Manual
Field Test 9
Tech Review of Design
Design Rev. by students
Need Revision?
yes
Revise Rules; Spinner
no
Duplicate Materials, Equipment
Field Test 10
Need Revision?
yes
Revise Action Sequence
no
Workshop Trial
Analyze Evaluation Data
Design Panel Review
Expert Review, Evaluation
Need Revision?
yes
Revise Design, Eval Forms
no
Phase 3 Field Tests Revised game
University students Field Tests
Collect, Analyze Data
Write Conclusions
End

Summative evaluation of simulation game's objectives

By 1988, the year of the Russian Orthodox Church's millennium and the year of the ecumenical study by North American Christians, the game was ready for use in eight additional Field Tests. In five settings the 75 players were members of Christian denominations and data from the revised evaluation instruments were analyzed in summative evaluation about the game's effectiveness in meeting its criterion-referenced objectives.

The current Decision Predictor (Appendix A) is designed to demonstrate changes in sympathetic understanding for Soviet Christians who are faced with daily dilemmas as they practice their faith. The participant is asked to respond **as-if** s/he were seeking to exercise some religious practice in the Sovet Union. Attitude change is measured on an agreement scale of [+3 to -3], a shift in the direction or strength of a self-report of one's own predicted behavior. Comparisons of responses on this Decision Predictor, both before and after play, are also useful in producing discussion during the game debriefing time.

The Revised Evaluation Form (Appendix B) elicits information to measure the game's criterion-referenced objectives. It also serves as a means of continued evaluation and revision of the game. Some unexpected patterns in results from earlier evaluations indicated that participants might be experiencing role empathy or identification with the Soviet citizens whom they play in the simulation. "Identification" is measured by a self report, the ability of a person to see similarities between himself and another. "Role empathy" is defined as the process of "feeling into" another person with "sympathetic (affective domain) understanding (cognitive elements).

Table 1 shows the data which measure results for Objective 1 from the game: "to cause identification with Soviet believers" by North American Christian players. Responses from 75 players yielded 78 reports of identification with one or more characters in the game. All but ten players reported identification with at least one character. Table 1 also shows a response pattern in these reports of identification: the greatest percentage of claims came from players who played that specific role during the game, supporting Williams' identification theory (1986). Game players' reports of identification met the 75% criterion for game Objective 1.

Table 1

Response by 75 North American Christians to Question 9 "Check any character with whom you could identify."

Character	N	#, % of Characters Claimed in Identification					
		Father	Mother	Daughter	Son	G.mother	Priest
Father	10	9 90%			1 10%		
Mother	23	1 4.3%	12 52.2%	3 13%	3 13%	2 8.7%	2 8.7%
Daughter	13	3 18.8%	2 12.5%	8 50.0%	2 12.5%	1 6.3%	
Son	14	2 28.6%	1 14.3%	1 14.3%	3 42.9%		
Gr.Mother	12		2 10.5%	3 15.8%	4 21.1%	8 42.1%	2 10.5%
Priest	3						3 100.%
Total	78						

Tables 2 and 3 show analysis of data in assessing how well Objective 2 for the game was met: "to increase sympathetic understanding about Soviet believers who experience dilemmas in the practice of their faith".

Two of the self-report questions on the Evaluation Form (Appendix B) provide data in assessing affective as well as cognitive reactions after playing the game. Question 5 asks about the usefulness of the simulation experience in learning new information with 76% of the players reporting a rating of "5" or above on a 7-point scale. Only 60% of players report such high ratings on Question 6 about the game's usefulness in attitude change, falling short of the 75% criterion.

However, when the raw data from the Decision Predictor are examined, all but four players reported **some** change in their predicted behavioral response to at least one of the six dilemmas presented during the game. For purposes of this study, there is no right or wrong answer, and a change in **either** direction can be counted as a sign of some shift in attitude after play. Table 2 shows such shifts for 20 players at Test Site #15. Table 3 then summarizes data from all five test sites.

Table 2

Site #15. Extent of each player's change on six dilemmas

	Amount of change per question						Total change per player, either way
Player	#1	#2	#3	#4	#5	#6	
1	2	3	0	0	2	2	9
2	2	2	1	1	1	3	10
3	1	4	2	2	0	3	12
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	1	0	0	0	1
7	2	1	3	3	4	0	13
8	2	2	0	0	0	2	6
9	0	0	0	1	0	1	2
10	1	2	0	2	0	0	5
11	1	1	0	0	3	0	5
12	1	1	1	1	1	1	6
13	2	4	3	0	3	0	12
14	0	1	2	1	2	0	6
15	1	0	0	1	1	0	3
16	1	2	3	0	3	3	12
17	0	1	1	0	4	2	8
18	3	3	3	3	3	3	18
19	2	2	4	4	4	4	20
20	1	1	2	3	1	3	11
20	22	30	26	22	32	27	159

Average shift per player for all six dilemmas = 7.95

Table 3

Average change for all players using Decision Predictor

	Field Tests, 5 N. A. Christian groups					
Category	#14	#15	#16	#17	#18	Total
Question #1	25	22	12	17	16	92
Question #2	15	30	7	22	20	94
Question #3	23	26	13	23	18	103
Question #4	22	22	22	24	12	102
Question #5	43	32	27	17	4	123
Question #6	15	27	10	7	6	65
Total spaces shifted	143	159	91	110	76	579
Total # of players	17	20	12	15	8	72
Average change	8.41	7.95	7.50	7.33	9.5	8.04

The extent of shift on post-game questionnaires of intended behavioral response shows an average change on this [+3 to -3] empathy scale that varies from 7.33 spaces for Test Site 17 to 9.5 spaces shift for Site 18. So far then, summative evaluation suggests that the game provides greater cognitive information than attitudinal shifts on players' self reports. However, responses of **intended behavior** in **either** direction on empathy scales show changes in players' ratings and support for the game's objective of greater sympathetic understanding for Soviet believers and the dilemmas which they face.

The third objective of the game is "to create a setting in which the influence of the group can be brought to bear upon decision making." This objective is measured by Questions 7 and 8 on the Evalution Form. Only one third of the players report that the influence on them from other players was "stronger than average". On the second question, only 28% of the players report "greater than average" success in influencing others' decisions during the game. As presently used the game does not meet the predicted criterion level for influence from the group discussion context.

Summary

Use of the Decision Predictor and Evaluation Form proved useful in formative evaluation of the simulation game, DISCRETION VS. VALOR, through eight 1987 revisions These measures also proved valuable during 1988 field tests by 75 North American Christians playing the revised DISCRETION VS. VALOR in five different settings. Data were gathered about how well the simulation game met its objectives and how well the criterion-referenced research hypotheses were supported. Results support Williams' "identification" theory and suggest further study. Use of a empathy scale provided data on behavioral intention to supplement players' self-reports of affective changes.

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REVISED APPENDIX A

DISCRETION VS. VALOUR: A Simulation by Barbara Blackstone

DECISION PREDICTOR _____Before playing the game; ______After playing

Pretend that you have to make each of these decisions in the USSR.
Circle the one that best decribes what you would do in this situation.

Definitely Yes +3	Probably Yes +2	Maybe Yes +1	Maybe Not -1	Probably Not -2	Definitely Not -3

1. If I had a Bible and access to some study guides, I would invite other Baptists to my home to read/study the Bible together. +3+2+1-1-2-3

2. If I had some musical ability, I would give practice in learning hymns to my son and two of his Baptist friends in our home. +3+2+1-1-2-3

3. If I were a 17-year-old in need of Soviet university education, I'd give up open worship & try to be a good Komsomol member. +3+2+1-1-2-3

4. If I were an 11-year-old with athletic aspirations, I'd join the Young Pioneers even it meant that I couldn't wear my cross. +3+2+1-1-2-3

5. As a grandmother on a pension in Moscow, I'd probably write letters to the newspapers if I felt human rights were being violated. +3+2+1-1-2-3

6. If my Orthodox priest friend were in prison for his outspokenness, I would visit him and attempt to smuggle in a Bible to him. +3+2+1-1-2-3

DECISION PREDICTOR _____Before playing the game; ______After playing

Pretend that you have to make each of these decisions in the USSR.
Circle the one that best decribes what you would do in this situation.

Definitely Yes +3	Probably Yes +2	Maybe Yes +1	Maybe Not -1	Probably Not -2	Definitely Not -3

1. If I had a Bible and access to some study guides, I would invite other Baptists to my home to read/study the Bible together. +3+2+1-1-2-3

2. If I had some musical ability, I would give practice in learning hymns to my son and two of his Baptist friends in our home. +3+2+1-1-2-3

3. If I were a 17-year-old in need of Soviet university education, I'd give up open worship & try to be a good Komsomol member. +3+2+1-1-2-3

4. If I were an 11-year-old with athletic aspirations, I'd join the Young Pioneers even it meant that I couldn't wear my cross. +3+2+1-1-2-3

5. As a grandmother on a pension in Moscow, I'd probably write letters to the newspapers if I felt human rights were being violated. +3+2+1-1-2-3

6. If my Orthodox priest friend were in prison for his outspokenness, I would visit him and attempt to smuggle in a Bible to him. +3+2+1-1-2-3

Circle the role you played: father-mother-daughter-son-grandmother-priest

REVISED-APPENDIX B

GAME EVALUATION FORM for DISCRETION Vs. VALOR:

Please circle one number and return to Barbara Blackstone. Date:_____

1. How much did you enjoy playing the game?

1 2 3 4 5 6 7
Very little — Very much

2. How easy was it to follow the instructions and rules of the game?

1 2 3 4 5 6 7
Very difficult — Very easy

3. How comfortable were you with the length of time that it took to play?

1 2 3 4 5 6 7
Very uncomfortable — Very comfortable

4. IF you were uncomfortable, was it too short?____ or too long?____

5. How helpful to you was this experience in learning new information about Soviet believers?

1 2 3 4 5 6 7
No help received — Very helpful

6. To what extent did this experience cause you to change your opinions about Soviet believers?

1 2 3 4 5 6 7
No change — A great deal

7. To what extent did other individuals help YOU make wiser decisions during the rounds of play?

1 2 3 4 5 6 7
No influence — Strong influence

8. How successful did you feel that you were in influencing other family members' decisions during the discussion before each round?

1 2 3 4 5 6 7
No influence — Very successful

9. Check any character with whom you felt you could identify (see yourself somewhat similar to them):

father?__ mother?__ son?__ daughter?__ priest?__ grandmother?__

Then circle the character that you played during the game.

10. What changes would you recommend in the game that would improve your understanding of Soviet Christians? (Use the back of this sheet.)

Title:

A Model for the Motivational Instruction of Adults

Authors:

Roy M. Bohlin
William D. Milheim
Karen J. Viechnicki

085

A Model for the Motivational Instruction of Adults

This paper provides educators with a model for the instructional motivation of adults. Adult learning theory has been integrated into John Keller's instructional motivation model to develop motivational needs-assessment survey instruments. Results of research eliciting adults' perceptions of their motivational needs were analyzed. Results show that: (a) instructional motivation has components of instructional appeal and learner effort and (b) specific instructional strategies are important for the motivation of adult learners. A model for the instructional motivation of adult learners is presented. This model provides an important step in the integration of adult learning theory into the design of motivational instruction for adult learners.

Introduction

Demographics suggest that during the next several years, the primary growth areas in U. S. education will be in adult and continuing education. By 1992, half of all college students will be over 25 and 25% will be over 35 (Hodgkinson, 1985). In addition, our American culture encourages adults to enroll in schooling. Recently, a group of experts presented a report to President George Bush in which they stated that Americans will increasingly change not just their jobs but their occupations, and will need regular retraining to learn new skills -- a life time of learning (American Agenda, 1988). This need for continuing education is increasingly being addressed by institutions of higher education, business and industry, and community agencies. We need to identify instructional strategies that best facilitate the continuing motivation of adult learners.

The purpose of this paper is to provide educators with a model for the motivating instruction of adult learners. This has been accomplished by linking significant adult learning theory with motivational instructional design; adapting survey needs assessment instruments from Keller and Subhiyah (1987); administering these instruments to adult learners; analyzing the needs-assessment responses; and outlining a model for the instructional motivation of adult learners.

Theoretical Framework

The underlying theory base for instruction of adults comes from two diverse arenas -- adult learning theory, and instructional design for motivation. John Keller (1983) supplies a framework for the design of motivational instruction for learners of all ages. Keller's ARCS model is based upon inductive analyses of the actual teaching practices of highly motivating instructors and deductive analyses of current learning and motivation theories (such as the work of such theorists as Gagne, Bruner, Bandura, Weiner, and Malone). Keller's ARCS model integrates a great amount of what we know about motivating learners, and supplies an organization for theory and practical applications.

Motivational Instructional Design. Instructional motivation attracts learners toward the instruction and increases their effort in relation to the subject (Keller, 1983). This means that instructional motivation has two components, appeal and effort generation. Motivational instruction, therefore, has appeal for the learner and stimulates learner effort.

Keller and Suzuki (1988) and Keller and Kopp (1987) also identify four categories of motivational "conditions" in learning situations: attention, relevance, confidence, and satisfaction. For facilitation of continuing motivation, these four conditions or stages should be addressed. Although these "conditions" (such as expectancy for success) interact with instructional methods to cause learner behaviors or attitudes, the "conditions" cannot be manipulated directly by the instructor. It is, instead, the methods or strategies of instruction that are under the instructor's control which produce various instructional consequences. The instructor, therefore, promotes motivation by using appropriate strategies.

The consequences, which result from the interaction of the methods with the learner's conditions, are termed "outcomes." Keller's model, therefore, is designed to provide effective instructional "methods" under particular "conditions" to yield desirable motivational "outcomes." The model, therefore, contains specific methods or strategies, that are aimed at producing motivational outcomes, when learners are lacking sufficient conditions, such as interest or motives. The initials of these four categories -- attention, relevance, confidence, and satisfaction--give Keller's model the acronym ARCS.

The first requirement for motivating instruction is to gain and maintain the attention of the learner. This can be achieved through several procedures aimed at increasing his/her curiosity or arousal, through humor, paradoxes, inquiry, etc.

Once attention is aroused, the learner evaluates the relevance of the environment before becoming highly motivated. The learner must also perceive that significant personal needs are being met by the instruction. This can be facilitated by matching instruction to learners' goals, using metaphors, cooperative atmosphere, etc.

Confidence is related to the learner's attitude toward success or failure. This attitude influences his/her actual effort and performance. Confidence can be cultivated by clearly indicating the requirements for success, allowing learner control, using learning organizers, etc.

Lastly, individual satisfaction is important for sustaining motivation. Learners must perceive the rewards gained as appropriate and consistent with their expectations. Learner satisfaction can be addressed through providing appropriate recognition for success, giving informative and corrective feedback, supporting intrinsic motivation, etc.

It is expected that the motivational factor of instructional appeal (how interesting and attractive the learner views the instruction) is more closely related to the categories of attention and relevance. The motivational factor of learner effort (the amount of effort a learner decides to give toward learning) is more closely related to the categories of confidence. Learner satisfaction is expected to be related to both interest and effort. These predicted relationships were investigated in this study.

Adult Learning Theory. Literature in adult education cites many strategies which are generalizable across levels of instruction. Authors such as Knowles (1980), Cross (1981), and Zemke and Zemke (1981), however, feel that adult learners have different instructional needs than younger students. These authors suggest strategies they feel to be particularly important for the instructional motivation of adults.

In order for adults to learn, they must be interested in an issue or subject, and it must grab their attention (Knowles, 1980). Adult learners usually are prepared to take responsibility for making choices about their own learning. Each adult student needs to be able to negotiate an individual course of study that is relevant to his or her own needs (Hull, 1981). Adults seek out learning because they have use for the knowledge or skill being taught (Zemke & Zemke, 1981). Learning is a means to an end, not an end in itself.

Adults must feel competent, exhibit confidence during learning, and should feel at ease in the learning environment (Knowles, 1980). Knowles states that confidence is built through self-evaluation, by comparing performance skills before and after the learning experience. This results in the re-diagnosis of learning needs. Further, expectations of the teacher are merged with those of the learner. Tough (1978) explains reasons adults choose their own way of learning by desiring to: (1) set their own learning pace, (2) use their own style of learning, (3) keep the learning flexible and easy to change, and (4) put their own structure on the learning project. Zemke and Zemke (1981) report that when adult learners are asked to risk new behavior in front of peers and cohorts, their self-esteem and ego are on the line. They must feel confident before they can perform in these situations.

According to Manteuffel (1982) satisfied learners are described as involved, challenged, self-directed, rewarded, and safe (i.e., feel comfortable to ask "stupid" questions). Zemke and Zemke (1981) state that an adult seeks to increase or maintain his/her sense of self-esteem and pleasure, which results in a feeling of satisfaction.

It has been suggested that some instructional strategies are more important for adult learners than for younger students. The integration of adult learning theory and the ARCS model provides a framework for a potential adult motivation model. This integration was analyzed through a needs-assessment instrument based upon the literature in both theory bases.

Methodology

This study surveyed adults in a variety of settings to determine their perceptions of their motivational needs. The subjects for the present study were 307 adult participants in Continuing Education at a major midwestern university from a variety of different classes and workshops, both credit and non-credit. While the majority of subjects were teachers and administrators of grades K-12, other occupations were also represented. Involvement in the study was voluntary and the sample included both men and women whose average age was approximately 39 years. Subjects were given a survey instrument during a course or workshop in order to determine their perceptions concerning their generalized personal motivation needs.

Instruments. The needs assessment instruments were developed through a revision of the Course Interest Survey (CIS) by Keller and Subhiyah (1987). Because the CIS was developed to evaluate a specific course, the survey was revised by the authors for better application to general instructional strategies. This was accomplished by a series of refinements from an earlier version of the instrument (Viechnicki, Bohlin, & Milheim, 1989). The statements were reworded in two ways, they were changed: (a) from past tense to present tense and (b) to refer more directly to instructional methods. Two statements that applied specifically to the quality of materials were omitted. Seven statements comprised of strategies suggested by the literature but not included in the CIS were then added. The Likert-type choices were changed from statements about actual instructor use to statements about the general effect of such strategies on either: (1) appeal of the instruction -- Course Interest Survey, Revised (CISR); or (2) effort of the learner -- Course Effort Survey, Revised (CESR). The resulting two instruments are 42-item five point Likert-type scales assessing learners perceptions of the effects of given instructor strategies on their interest and effort in instructional settings (see Table 1).

The Course Interest Survey Revised (CISR) and the Course Effort Survey Revised (CESR), therefore, include items drawn from the integration of adult learning and general motivational factors also relevant to adult learners. The instruments are designed to measure respondents' perceptions of their instructional needs related to instructional appeal (CISR) and learner effort (CESR). Typical demographic questions have also been added to both instruments.

Each of the statements was rated by all subjects on a five-point scale as to the expected effect with the number 5 indicating a very positive effect, and 1 a very negative effect. The test-retest reliabilities of the instruments over a two-week period were found to be .69 (CISR) and .71 (CESR).

Procedure. The administration of the instrument was carried out over a four month period in a number of different classes and workshops. The classes and workshops were selected to give a balanced stratified sampling that reflected a general graduate and continuing education population. After receiving instructions, all subjects worked through the survey form and recorded their answers to each item on a machine-scorable answer sheet. Each administration of this survey required approximately fifteen minutes of class time.

Data analyses were carried out on an IBM 4381 using SPSS-X. In addition to item frequencies across all subjects and subgroups for both surveys, the analyses also included t-tests to determine whether any numerical differences for items and for subscales across the two surveys were significant for this group.

Results

Most of the items were rated by the respondents as having at least a slightly positive effect on their interest and effort (see Tables 2 and 3). The very high ratings of many of the items suggests a possible ceiling effect. The results, however, can be used to analyze certain trends.

Responses differed on the two instruments in several ways. Ratings were higher for interest than for effort on 41 of the 42 items. T-tests showed the ratings on the CISR to be significantly higher ($p < .05$) for 18 of the items, and for all four subscales.

The 42 items were also ranked by mean response on each instrument (see Table 4). As expected, there were differences in the rankings of many items on the two instruments. Large differences in rankings between the two instruments were defined as those ordinal differences in rankings above the third quartile (ordinal differences of 6 or more for this data). These large differences in the rankings between the instruments were also identified (see Table 4) and analyzed.

Using this criteria, four items in the confidence subscale had large differences in rankings and all four strongly favored perceived effort. This seems to supports the contention that confidence is more closely related to effort than to interest. The relevance and satisfaction subscales each had two items with large differences favoring interest and one item with a large difference favoring effort. The attention subscale showed no large differences in rankings.

Conclusions

These results suggest that instructional strategies can have a positive effect on the interest and effort of adult learners. Differences in the mean responses and in the rankings of the items also support the definition of instructional motivation as including both instructional appeal and learner effort. The results further suggest that many instructor's motivational methods are perceived to have a stronger positive effect on adult learners' interest than on adult learners' effort in learning. It is easier to stimulate arousal and interest than to impact on the effort of adult students. Confidence building strategies were found to be much more strongly linked to perceived effort of learners than to instructional appeal. Attention, relevance and satisfaction promoting strategies were not clearly linked more strongly to interest or to effort.

Based upon instructional motivation theory, adult learning theory, and these results, an adult-learner/instruction interaction motivation model has been developed (see Figure 1). This model, based in part on Keller's (1983) work, shows the suggested interaction of methods, conditions, and outcomes for the motivational instruction of adults. Methods are organized as to the suggested effects on appeal, effort, and satisfaction.

This model is a beginning step in the development of prescriptions for the instructional motivation of adult learners and for the organization of research in adult motivation. Because this study only looked at adult learners in graduate level classes and continuing education workshops, these results may not be generalizable to other adult learners. Further research is, therefore, needed to investigate the perceptions of adult learners in other types of instructional settings. Research to investigate the actual effects (as opposed to perceived effects) of instructional strategies on the interest, effort, and performance of adult learners is also indicated.

The motivation of adult learners was investigated in relation to interest and effort. Research looking at further affective outcomes of these strategies is suggested. Other important outcomes which should be investigated would include learners' attitudes, feelings, values, and emotions.

Research across all age groups is needed to investigate any differences in the instructional motivation needs of learners of different ages. While the literature suggests that adult learners have different needs than other learners, there appears to be little research to support those contentions. To the extent that this data is generalizable to other adults, this model can be used by designers of instruction for adult learners. Specific strategies can be used during the instructional process to enhance the motivational elements of instruction.

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Table 1

Paraphrased Needs Assessment Items Broken Down by Subscale

Attention	Item 1	Instructor makes me feel enthusiastic about subject
	Item 2	Class captures my attention
	Item 3	Instructor uses humor
	Item 4	Instructor makes me feel curious about subject matter
	Item 5	Instructor does unusual or surprising things
	Item 6	I get a chance to actively participate
	Item 7	Interesting variety of teaching techniques are used
	Item 8	Curiosity is stimulated by questions and problems
Relevance	Item 1	Learning will be useful to me
	Item 2	Instructor makes subject seem important
	Item 3	I can see how content is related to what I already know
	Item 4	I can set and achieve high standards of excellence
	Item 5	Positive role models are presented
	Item 6	Instructor is flexible to meet my needs
	Item 7	Personal benefits are made clear
	Item 8	The challenge level is not too easy or too hard
	Item 9	Amount of work is appropriate
	Item 10	I have input in content and assignments
	Item 11	I get a chance to work with other people
	Item 12	Content relates to my expectations and goals
Confidence	Item 1	Instructor helps me feel confident
	Item 2	Instructor helps feel success isn't linked to luck
	Item 3	Instruction doesn't threaten my self-esteem
	Item 4	Whether or not I succeed is up to me
	Item 5	Instructor creates relaxed atmosphere
	Item 6	Instructor allows for practical applications
	Item 7	Requirements for success are made clear to me
	Item 8	There are frequent opportunities to succeed
	Item 9	Instructor links success to my goals
	Item 10	Instructor helps me feel I can succeed with effort
	Item 11	Instructor models and demonstrates proper skills
	Item 12	The instruction is non-threatening
Satisfaction	Item 1	The class gives me a lot of satisfaction
	Item 2	The recognition I receive is fair compared to others
	Item 3	I will benefit from the knowledge acquired
	Item 4	My instructor's evaluations match my perceptions
	Item 5	I am not disappointed with the course
	Item 6	I get enough recognition from the instructor for my work
	Item 7	I feel satisfied with what I learn
	Item 8	I get enough timely feedback to know my progress
	Item 9	I benefit from this class
	Item 10	Instruction is designed so everyone can succeed

Table 2

Means and Standard Deviations of Responses to Each Item in Course Interest Survey (CISR) Subscales

	Attention	Relevance	Confidence	Satisfaction
Item 1	4.81 (.40)	4.84 (.40)	4.47 (.62)	4.61 (.58)
Item 2	4.12 (1.08)	4.39 (.64)	4.30 (.92)	4.24 (.80)
Item 3	3.70 (.96)	4.05 (.94)	4.48 (.79)	4.75 (.45)
Item 4	4.47 (.60)	4.55 (.58)	3.87 (1.01)	4.39 (.66)
Item 5	4.21 (.72)	4.10 (.74)	4.43 (.65)	4.32 (.88)
Item 6	4.01 (.84)	4.32 (.69)	4.41 (.71)	4.21 (.72)
Item 7	4.32 (.77)	4.26 (.72)	4.56 (.59)	4.33 (.70)
Item 8	4.51 (.64)	4.17 (.82)	4.38 (.63)	4.59 (.58)
Item 9		4.40 (.68)	3.28 (1.02)	4.52 (.78)
Item 10		4.02 (.81)	4.20 (.76)	3.77 (1.04)
Item 11		3.78 (.86)	4.37 (.69)	
Item 12		4.48 (.62)	4.47 (.73)	

Key:
1 = very negative effect
2 = slightly negative effect
3 = no effect
4 = slightly positive effect
5 = very positive effect

n = 161

Table 3

Means and Standard Deviations of Responses
to Each Item in Course Effort Survey (CESR) Subscales

	Attention	Relevance	Confidence	Satisfaction
Item 1	4.69 (.80)	4.71 (.68)	4.41 (.76)	4.38 (.85)
Item 2	4.08 (.96)	4.10 (.78)	4.19 (.94)	4.08 (.83)
Item 3	3.63 (.89)	3.98 (.93)	4.34 (.87)	4.55 (.68)
Item 4	4.29 (.67)	4.41 (.76)	4.06 (.90)	4.25 (.72)
Item 5	4.02 (.74)	3.84 (.73)	4.22 (.69)	4.18 (.91)
Item 6	3.87 (.83)	4.13 (.74)	4.36 (.76)	3.94 (.70)
Item 7	4.15 (.78)	4.06 (.76)	4.30 (.84)	4.29 (.76)
Item 8	4.36 (.69)	4.12 (.90)	4.13 (.82)	4.27 (.69)
Item 9		4.18 (.75)	3.19 (.92)	4.41 (.83)
Item 10		3.86 (.87)	4.05 (.76)	3.63 (1.00)
Item 11		3.44 (.86)	4.12 (.73)	
Item 12		4.17 (.72)	4.24 (.97)	

Key: 1 = very negative effect

2 = slightly negative effect

3 = no effect

4 = slightly positive effect

5 = very positive effect

n = 126

Table 4

Rankings of Effort and Interest Needs Assessment Items

		Rankings				Rankings	
Category	Item	Effort	Interest	Category	Item	Effort	Interest
Attention	1	2	2	Confidence	1*	4t	12t
	2	28t	33		2*	18	26
	3	39t	42		3	10	10t
	4	12t	12t		4*	30t	38
	5	33	29t		5	17	15
	6	36	37		6*	8t	16
	7	22	23t		7	11	6
	8	8t	9		8	23t	20
					9	42	41
Relevance	1	1	1		10	32	31
	2*	27	18t		11	25t	21
	3	34	35		12	16	12t
	4	4t	7				
	5	38	34	Satisfaction	1	7	4
	6	23t	23t		2	28t	28
	7	30t	27		3	3	3
	8*	25t	32		4	15	18t
	9	19t	17		5	19t	23t
	10	37	36		6*	35	29t
	11	41	39		7*	12t	22
	12*	21	10t		8*	14	5
					9	4t	8
					10	39t	41

t = tied rankings
* = large difference in ranking (above third quartile)

Title:

Curriculum Development System for Navy Technical Training

Author:

Lucius Butler

NAVAL TECHNICAL TRAINING SYSTEM

1. The U. S. Navy is constantly engaged in technical training as technology is applied to ships at sea and warfare in general. The entrance into the Navy by young people each year requires basic technical training followed by advanced technical training as these sailors move up the ranks in their career.

2. Training requirements are derived from the need for people with particular skills in the Fleet. Skill requirements are maintained by the Chief of Naval Operations (CNO) OP-01 in the Enlisted Billet File, which lists the ratings and their associated Naval Enlisted Classification (NEC) Code. Formal courses are taught in each skill area unless enough people with that skill are already in the trained inventory or it is decided that skill may be obtained most cost effectively through on-the-job training (OJT).

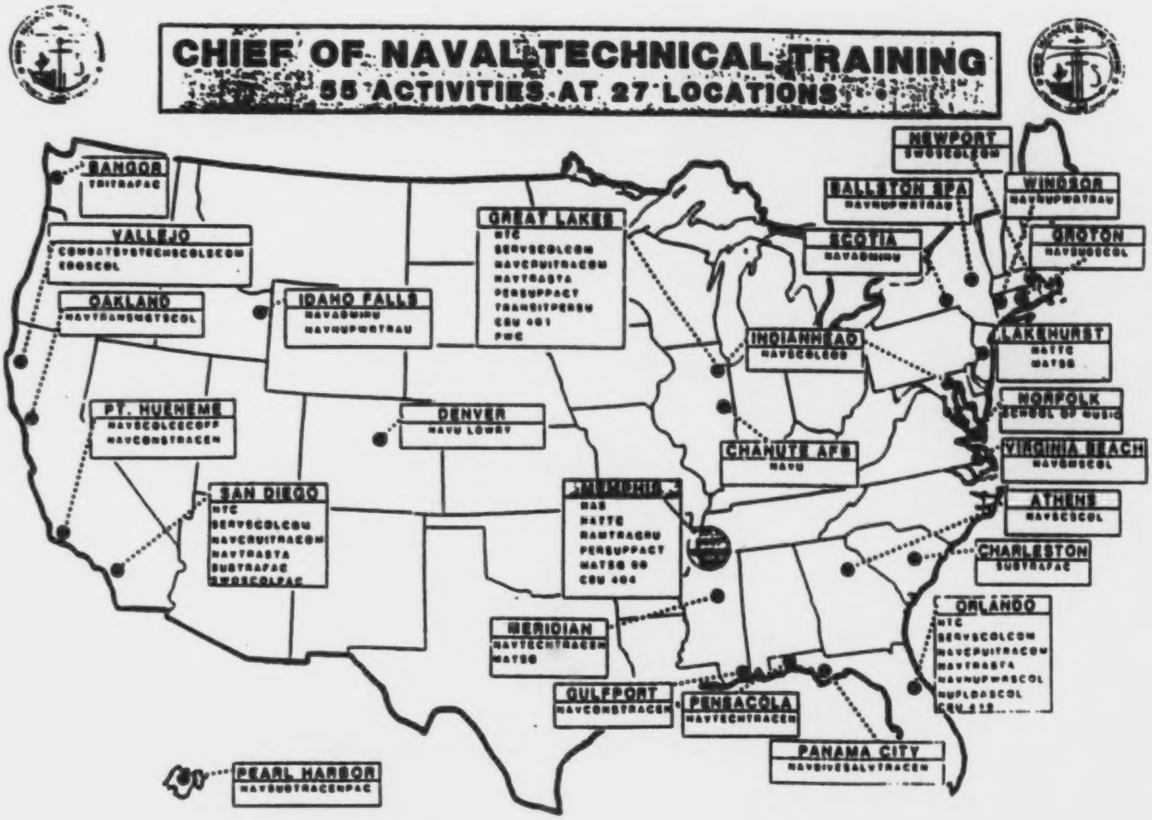
3. The Navy currently provides most initial skill training via formal courses and almost all NEC training is provided by formal Class C courses. Old courses are deleted when the skill requirements become obsolete, usually through the process of introducing new technology. New courses are introduced to meet the new skill requirements resulting from the purchase of new systems or equipment.

4. The Navy Training Plan (NTP) process is the current mechanism for the introduction of new courses. This formal process is as follows: First, someone (usually a systems command) determines the need for training. They define the skills that are required to operate or maintain a new system or piece of equipment; second, this need is followed by technical program data on the system or piece of equipment in question; third, the CNO convenes a Navy Training Plan Conference attended by fleet representatives, the concerned warfare desk, OP-01, representatives of the training community and other concerned bureaus or commands; fourth, the NTP is reviewed, validated, approved and distributed; and finally, the NTP is implemented. NTPs are supposed to be developed and approved at least three years before the introduction of new equipment into the fleet.

5. The Chief of Naval Education and Training (CNET) is responsible for providing policy, direction and overall management for initial recruit and most advanced specialized training. There are within CNET three functional commands with operational responsibility for different spheres of recruit and specialized training. The Chief of Naval Technical Training (CNTECHTRA) in Memphis manages all recruit training, most initial skill and skill progression training and some functional training. The Commander, Training Command Atlantic (COMTRALANT) and Commander, Training Command Pacific (COMTRAPAC) manage a few initial skill and skill progression courses but are primarily concerned with courses of short duration which are usually operational in nature.

6. Technical training in the Navy is a responsibility of the Chief of Naval Technical Training (CNTECHTRA) located at Naval Air Station, Memphis, Tennessee. CNTECHTRA Training Program Coordinators (TPC) are responsible for all training for specific ratings or groups of ratings. They compare the desired input with the training capacity of various training facilities and identify resource problems (other than manpower) i.e., equipment or space constraints.

7. Training Facilities (TF) under CNTECHTRA teach existing formal courses as listed in the Catalog of Naval Training Courses (CANTRAC). The trainees come to the school from a variety of sources and include officers, enlisted and civilian personnel of the Navy and other military services, including those from other nations. These facilities are shown on the map below.


CHIEF OF NAVAL TECHNICAL TRAINING
55 ACTIVITIES AT 27 LOCATIONS
BANGOR
TRITRAFAC
VALLEJO
COMBATSYSTECHSCOLSCOM
EODSCOL
OAKLAND
NAVTRANSMGTSCOL
IDAHO FALLS
NAVADMINU
NAVNUPWRTRAU
GREAT LAKES
NTC
SERVSCOLCOM
NAVCRUITRACOM
NAVTRASTA
PERSUPPACT
TRANSITPERSU
CSU 401
PWC
PT. HUENEME
NAVSCOLCECOFF
NAVCONSTRACEN
DENVER
NAVU LOWRY
SAN DIEGO
NTC
SERVSCOLCOM
NAVCRUITRACOM
NAVTRASTA
SUBTRAFAC
SWOSCOLPAC
MEMPHIS
NAS
NATTC
NAMTRAGRU
PERSUPPACT
NATSG 90
CSU 404
MERIDIAN
NAVTECHTRACEN
NATSG
GULFPORT
NAVCONSTRACEN
PENSACOLA
NAVTECHTRACEN
PANAMA CITY
NAVDIVESALVTRACEN
PEARL HARBOR
NAVSUBTRACENPAC
NEWPORT
SWOSCOLCOM
BALLSTON SPA
NAVNUPWRTRAU
WINDSOR
NAVNUPWRTRAU
SCOTIA
NAVADMINU
GROTON
NAVSUBSCOL
INDIANHEAD
NAVSCOLEOD
LAKEHURST
NATTC
NATSG
NORFOLK
SCHOOL OF MUSIC
CHANUTE AFB
NAVU
VIRGINIA BEACH
NAVGMSCOL
ATHENS
NAVSCSCOL
CHARLESTON
SUBTRAFAC
ORLANDO
NTC
SERVSCOLCOM
NAVCRUITRACOM
NAVTRASTA
NAVNUPWRSCOL
NUFLDASCOL
CSU 412

LONG RANGE DEVELOPMENT PROCESS

1. Introduction: The curriculum development process for Navy Technical Training begins about three years before the instruction of the course is scheduled to begin. The process is diagramed below to show the normal flow of development which may be changed to meet changing conditions in equipment or systems delivery to the Navy.

ACTION REQUIRED	Needs Assessment	PPP Table Development	TPS Development	Training Materials Development System	
ACTION TAKEN	Funding and Billets	TASK ANALYSIS	JOB ANALYSIS	Stages 1-3 PLANNING, DEVELOPMENT	Stages 4-5 VALIDATION, IMPLEMENTATION
PRODUCT PRODUCED	NAVY TRAINING PLAN-3yrs previous	PPP Table Completed	TLA Completed	Training Materials Completed - Instructor Guide - Trainee Guide/Test Materials - Instructional Media Materials	

2. The Training Materials Development System (TMDS) consists of five stages as shown below. Each stage is completed by the Materials Production Activity (MPA) which may be a Training Facility (TF) producing the materials on an in-house basis or utilizing a contract with an outside contracting production organization. The second stage, developing sample materials, is often waived when the TF or contractor has had previous satisfactory materials development experience.

FIVE STAGES OF THE TRAINING MATERIALS DEVELOPMENT SYSTEM(TMDS)

Stage 1: Plan, schedule, outline training materials

Stage 2: Develop sample training materials unless waived

Stage 3: Complete draft development of all training materials

Stage 4: Hold a pilot course for validation of training materials

Stage 5: Promulgate, distribute materials and begin surveillance

TRAINING MATERIALS DEVELOPMENT SYSTEM OUTLINE

1. Introduction. The Training Materials Development System (TMDS) is a five stage process by which curriculum developers operate, within current regulations and instructions, to provide materials for Navy training.

2. Methods of training materials development.
   a. Factory training development
   b. Contracting-out development
   c. In-house development

3. Documents utilized.
   a. Military Standard: Contract Training Programs MIL-STD-1379C (NAVY)
   b. Military Handbook: Training Materials Development DOD-HDBK 292
   c. Training Materials Acquisition and Management Plan NAVEDTRA 38004A
   d. Development, Review and Approval of New or Modified Training Curricula OPNAVINST 1550.8B
   e. Testing and the Measurement of Trainee Achievement CNTECHTRAINST 1540.38B

4. Management Participants
   a. Curriculum Control Authority (CCA)
   b. Course Curriculum Model Manager (CCMM)
   c. Training Facility (TF)
   d. Material Preparing Activity (MPA)
   e. Training Program Coordinator (TPC)
   f. Materials Change Activity (MCA)
   g. Materials Support Activity (MSA)

5. Establishment of need for course
   a. Navy Training Plan (NTP) - Factory training curriculum
   b. Training Project Plan (TPP) - Existing equipment/system

6. Process of curriculum development - five stages.
   a. Pre-development management documents - NETPMSA See page 6
      (1) Personnel Performance Profile (PPP) tables See page 7
      (2) Training Path System (TPS) components See page 8

   b. Stage 1: Scheduling and planning - deliverables See page 9
      (1) Topical Outline (TO) with Course Learning Objective (CLO)
      (2) Topic Learning Objectives (TLO)
      (3) Testing procedures
      (4) Preliminary Master Materials List (MML)
      (5) Preliminary PPP-item-to-topic objective Assignment Chart (OAC)
      (6) Curriculum materials status and development schedule
      (7) Flow chart diagram of Stage 1 See page 10

Outline (continued)

6. Process of curriculum development - five stages (continued)

c. Stage 2: Cross sectional sample of curriculum materials
(1) Section of Instructor Guide (IG)
(2) Section of Trainees Guide (TG)
(3) Sample of Instructional Media Materials (IMM)
(4) Sample Test
Note: this stage is usually waived for in-house development

d. Stage 3: Complete draft-development of curriculum - deliverables
(1) Instructor Guide (IG)
(2) Trainee Guide (TG) or seperate Instruction Sheets See page 12
(3) Instruction Media Materials (IMM) masters See pages 13-16
(4) Proctor Guides and Testing Plan
(5) Preliminary Master Schedule
(6) Flow chart diagram for Stage 3 See page 17

d. Stage 4: Pilot course validation of curriculum - components
(1) Purpose of Conducting a Pilot Course
(2) Preparing for Pilot Course Convening
(3) Pre-pilot Conference Agenda
(4) Pilot course Monitoring Team Responsibilities
(5) Conducting the Pilot Course
(6) Pilot course Final Report
(7) Flow chart diagram for Stage 4 See page 19

e. Stage 5: Authorized Curriculum Managed and Modified See page 20
(1) Promulgation, production and distribution of materials
(2) Course implementation at Training Facilities See page 20
(3) Navy training appraisal system See page 21
(4) Curriculum materials modification system See page 22

Note: The process of curriculum modification follows some of these same steps, particularly when a "Revision" of the curriculum is required.

Training Materials Development System
PRE-DEVELOPMENT MANAGEMENT DOCUMENTS REQUIRED

A. INTRODUCTION. This is a summary of the documents required as the basis to begin stage one of the Training Materials Development System (TMDS). The references utilized to develop these pre-development documents are also listed.

B. REFERENCES.
1. NAVEDTRA 38004 REV A
2. Military Standard 1379C (NAVY) with Data Item Descriptors (DID)
3. DOD Handbook 292, Parts 1 and 2
4. NETPSMA Quarterly Report

C. INFORMATION. Usually there is a Navy Training Plan. Two additional major documents are required in order to effectively develop course materials.

1. Personnel Performance Profile Tables (PPP)

a. The Personal Performance Profile is a behavior-oriented tabular listing of skills and knowledge to support a subject. A PPP table consists of a series of PPP items derived from job and task analysis.

b. Five types of PPP tables are used for the following purposes:
(1) System (made up of several sub-systems)
(2) Sub-system (made up of several related items of equipment)
(3) Equipment (including related accessory items)
(4) Task/Function (dealing with one task or function)
(5) Background (generalized academic information)

2. Training Path System (TPS)

a. The Training Path System is used by management to determine which PPP items were selected by the Subject Matter Expert (SME) to form the basis of a course and determine at what "level" of training the PPP items will be taught. Also, the relationship of the new course to all other related courses for a particular Navy Enlisted Classification (NEC) or officer training program.

b. The Training Path System consists of the following components:

(1) Training Objective Statements (TOS) which modify PPP items to indicate the level of training for each of three "task sets" representing three types of Navy personnel. Codes used indicate levels to instructors.

(2) Training Level Assignment (TLA) is a matrix showing the TOS levels selected for each PPP item previously selected.

(3) Training Path Chart (TPC) comprising three "tables":
(a) Table Assignment Matrix (TAM)
(b) Table index of PPP tables
(c) Table Assignment Chart (TAC)

3. In the event that these documents are not provided by the Curriculum Control Authority (CCA) and are not available from NETPSMA, guidance from the Training Program Coordinator at the Chief of Naval Technical Training.

4. PPP tables are developed from job analysis and task analysis efforts.

The definition of Personnel Performance Profiles (PPP) tables is as follows:

A list of knowledge and skill requirements for:

1. the operation and maintenance of a:
    a. system
    b. sub-system
    c. item of equipment,
2. performance of a task or function, or
3. generalized academic background information

5. PPP tables are used in curriculum development as the basis for:

1. the design, development and management of training, and
2. the development of these curriculum development documents:
    a. Training Path System (TPS)
    (to show how the course fits into total training)
    b. Topic Outline (TO)
    (to provide an overview of the course scope and sequence)
    c. Topic Learning Objectives (TLO)
    (to show the specific knowledge and skills to be learned)
    d. Test Items
    (to indicate methods of trainee assessment)
    e. Instructional Media Materials (IMM)
    (to provide the instructor and trainee with learning aids)

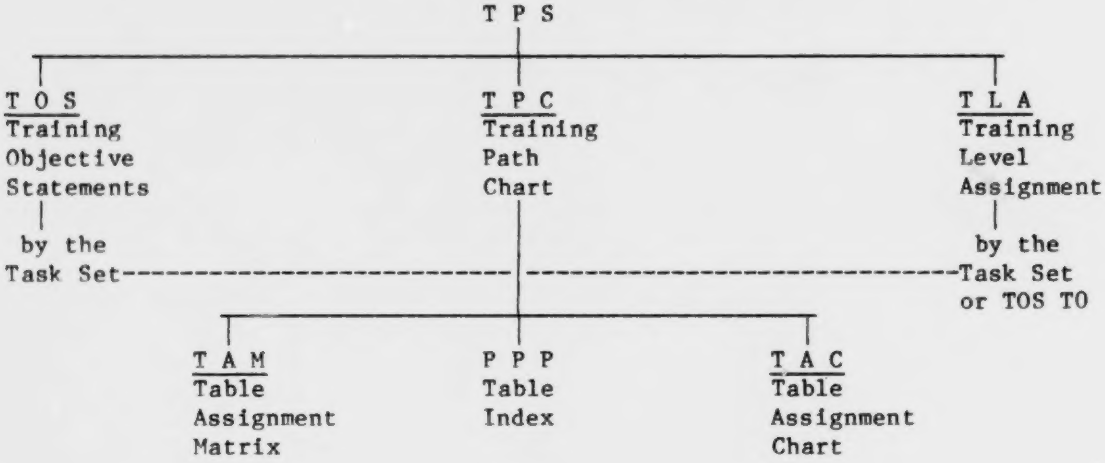
6. PPP tables for equipment, subsystems and systems are organized according to the following outline:

1 - KNOWLEDGE (THEORY) Describing the equipment, system, sub-system.
    1-1 General Desciption
    1-2 Physical Description
    1-3 Functional Description
    1-4 Interface Description
    1-5 OPERATIONAL DESCRIPTION (directly related to skills)
    1-6 MAINTENANCE DESCRIPTION (directly related to skills)
    1-7 Documentation Description

2 - SKILLS (PERFORMANCE) Listing the performance to be accomplished.
    2-1 OPERATION
    2-2 MAINTENANCE

7. The Training Path System (TPS) components can be diagramed as follows:

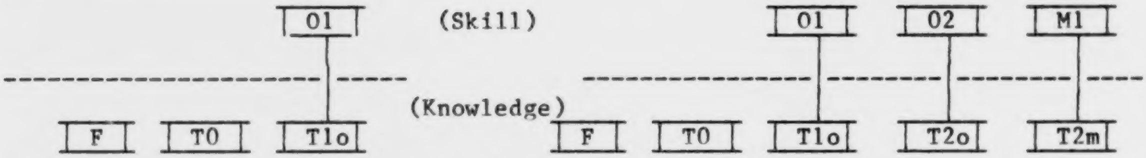
TRAINING PATH SYSTEM (TPS) COMPONENTS


T P S
T O S
Training
Objective
Statements
by the
Task Set
T P C
Training
Path
Chart
T L A
Training
Level
Assignment
by the
Task Set
or TOS TO
T A M
Table
Assignment
Matrix
P P P
Table
Index
T A C
Table
Assignment
Chart

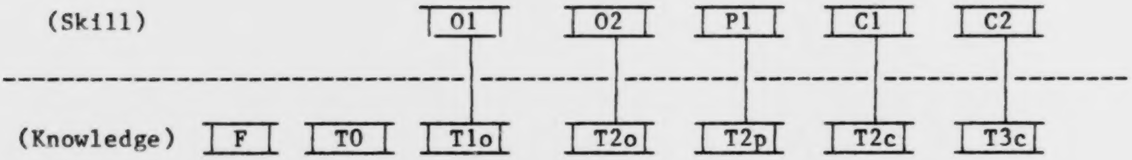
8. The three Task Sets are Coordinate, Direct and Perform and each deal with different Navy personnel. These task sets are diagramed below, using TOS codes.

COORDINATE TASK SET (TOS Codes)
(Commanding/Executive Officers)

DIRECT TASK SET (TOS Codes)
(Officers except CO/XO)


01
(Skill)
(Knowledge)
F
TO
T1o
01
02
M1
F
TO
T1o
T2o
T2m

PERFORM TASK SET (TOS Codes)
(Technicans)


(Skill)
01
02
P1
C1
C2
(Knowledge)
F
TO
T1o
T2o
T2p
T2c
T3c

Training Objective Statements (TOS) differ for each of three Task Sets. Thus the T1o (Theory level 1 for Operation) training objective statements for the Coordinate, Direct and Perform Task Sets will each be different statements.

Training Materials Development System
STAGE ONE CURRICULUM DELIVERABLES

A. INTRODUCTION. This is a summary of the materials required for stage one deliverables and provides the document references for each item.

B. REFERENCES.
1. NAVEDTRA 38004 REV A
2. Military Standards 1379C (NAVY) with Data Item Descriptors (DID)
3. DOD Handbook 292, Part 2
4. CNTECHTRAINST 1540.38B

C. INFORMATION. The basic list of stage one requirements is found in NAVEDTRA 38004 REV A, Chapter 4, paragraph 4-3.2 a through g.

1. Course Learning Objective (CLO) (included in Topical Outline)
This multiple-statement objective indicates what the trainee will be able to describe and perform when the course has been successfully completed.

2. Topical Outline (by part, section and topic)
Sequencing of the total course into sections and topics to identify the scope and flow of the material. A statement of rationale is included for each section and topic to support inclusion into the course.

3. Topic Learning Objectives (TLO)
A series of statements forming the "backbone" of the course which indicate what the trainee will describe and perform upon completion of the topic. Topic Learning Objectives are composed for three parts:
   (a) Behavior - from the PPP line item
   (b) Condition - from the TOS training level phrase
   (c) Standard - either stated or implied to be 100%

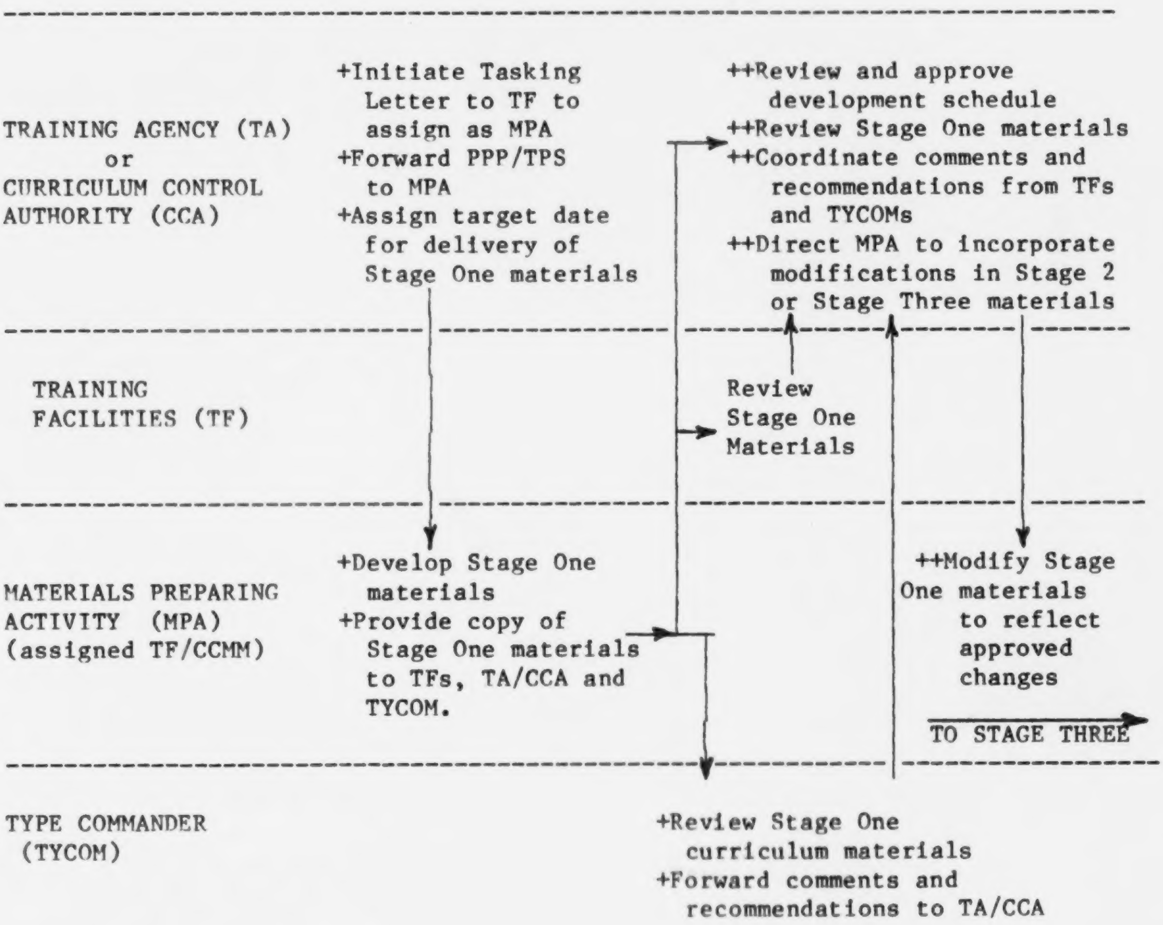
4. Preliminary PPP-Item-to-Topic Objective Assignment Chart (OAC)
A matrix format to relate each PPP line item to the Part-Section-Topic of the Instructor Guide (IG), the Topic Learning Objectives of the topic, and the individual test items which are used to evauate each topic learning objective.

5. Tests and testing procedures
A draft of the procedures to be used in trainee evaluation during the course. May include some sample knowledge test items and performance checklists.

6. Preliminary Master Material List (MML)
A draft list of all the publications, materials, equipment, tools, expendables, etc. that are required to teach the course.

7. Curriculum Materials Status and Development Schedule
A schedule to show the start and completion of each stage of curriculum development by year, month and day as it is planned by the curriculum developer.

FLOW DIAGRAM FOR CURRICULUM DEVELOPMENT - STAGE ONE



TRAINING AGENCY (TA)
or
CURRICULUM CONTROL
AUTHORITY (CCA)

+Initiate Tasking Letter to TF to assign as MPA
+Forward PPP/TPS to MPA
+Assign target date for delivery of Stage One materials

++Review and approve development schedule
++Review Stage One materials
++Coordinate comments and recommendations from TFs and TYCOMs
++Direct MPA to incorporate modifications in Stage 2 or Stage Three materials

TRAINING
FACILITIES (TF)

Review Stage One Materials

MATERIALS PREPARING
ACTIVITY (MPA)
(assigned TF/CCMM)

+Develop Stage One materials
+Provide copy of Stage One materials to TFs, TA/CCA and TYCOM.

++Modify Stage One materials to reflect approved changes

TO STAGE THREE

TYPE COMMANDER
(TYCOM)

+Review Stage One curriculum materials
+Forward comments and recommendations to TA/CCA

Training Materials Development Ssystem
STAGE THREE CURRICULUM DELIVERABLES

A. INTRODUCTION. This is a summary of stage three materials to be delivered to the Training Agency and provides the references utilized to develop each item.

B. REFERENCES.

1. NAVEDTRA 38004 REV A
2. Military Standard 1379C (NAVY) with Data Item Descriptors (DID)
3. DOD Handbook 292, Part 2
4. CNTECHTRAINST 1540.38B
5. CNTECHTRAINST 1540.8C

C. INFORMATION. The stage three requirements as shown below are in their completed final draft form in preparation for course validation in stage four.

1. Instructor Guide (IG) components
   (a) Front Matter: table of contents, how to use, etc.
   (b) Parts: sections, topics, discussion-demonstration-activity pages
   (c) References: master materials list, objective assignment chart, etc.

2. Trainee Guide (TG) components
   (a) Front Matter: hazard awareness, list of effective pages, etc.
   (b) Instruction Sheets: six types for different uses

3. Instructional Media Materials (IMM)
   (a) Used to supplement and aid in learning and teaching
   (b) Six categories from audiovisual to team training

4. Testing plan components
   (a) What examinations will be given at which times during the course
   (b) Written examinations
   (c) Performance examinations and laboratory work
   (d) Testing constraints and weighting criteria for computing grades

5. Test item types and tests
   (a) Item types: True-False, Multiple-Choice, Completion, Matching, Essay
   (b) Test types: Knowledge and Performance, Within-course and End-of-Course

6. Preliminary Master Schedule

Represents "best guess" of curriculum developer as to number of hours needed for each topic of classroom, lab and testing activities. This will be checked during the Stage Four pilot course validation activity.

TRAINEE INSTRUCTION SHEET MATRIX

1. Trainee instruction sheets are provided to assist the trainee in the study of the topic under consideration. The concepts of saving trainee time, supplementing training manuals under revision, providing guidance during class notetaking, etc. are aimed at helping the trainee learn as much as possible.

TYPE	INSTRUCTIONAL PURPOSE	ELEMENTS INCLUDE:	ADVANTAGES
Assignment "homework"	1. Simplify trainee search for relevant data needed. 2. Direct trainee efforts to complete an assignment.	Title describes content area; TLO from the IG; Study assignment with appropriate documentation; Study questions to test application of information	1. Saves trainee home study time. 2. Provides initial experience in use of reference materials.
Information "supplement"	1. Cover inadequacies in technical manuals. 2. Aid trainees comprehension of subject matter.	Title describes content area; Introduction explains purpose & benefit; References list sources used; Information is material at level understood by trainee	Provides trainee with current accurate supplementary data to update training manual material.
Problem "application practice"	1. Present trainees with practical problems to emphasize the fundamentals of logical thinking. 2. Give practice in knowledge application to problem solving.	Title describes problem content area; Format: 1. Clear statement of the problem to be solved. 2. Conditions with any parameters involved. 3. Directions and procedures for soluation.	Permits troubleshooting problem soluation without requiring use of equipment to supplement the regular laboratory exercises.
Job "performance evaluation"	Direct trainees to utilize documentation as the basis for a step-by-step performance of a practical job in operating or maintaining equipment.	Title describes content area of job; Introduction explains purpose concisely; Equipment list; Reference materials; Job Steps:gives step-by-step procedures with self-test questions.	Provides trainees with practice in performance of a job as they will do in their ultimate job assignment.
Diagram "visualized"	Provide trainees with course material without the need to copy the chalkboard or overhead transparency material which the instructor deems important to use.	Title describes subject matter involved; Format: varies, such as: 1. Foldout schematics 2. Block diagrams 3. Illustrations	1. Saves time in the classroom. 2. Assures that trainees have accurate information to work with.
Outline "overview"	Provide trainees with outline of major teaching points of a topic.	Title identical with topic; Format: 1. Introduction,eg.TLO's 2. Outline in key words	1. Cuides trainee in note-taking. 2. Provides an overview of topic

INSTRUCTIONAL MEDIA MATERIALS MATRIX

TYPE	DESCRIPTION	EQUIPMENT REQUIRED	ROOM LIGHTING	ADVANTAGES
AUDIO-VISUAL PRESENTATION CATEGORY				
1. Chalkboard or Visual-Aid Panel (VAP)	Slate / painted wood or metal to accept chalk or special VAP markers.	Chalkboard or VAP hung on the wall. May be magnetized.	Normal room lighting	1. Always ready for use during presentation. 2. Easily erased when finished with material. 3. Can be prepared prior to class and covered.
2. Transparency	Transparent acetate or plastic film with opaque printing on it	Overhead projector and screen	Room can remain lighted	1. Instructor faces the class. Good eye contact 2. Flexible sequencing. 3. Instructor may add to transparency during presentation.
3. Films	8mm or 16mm motion picture film	8mm or 16mm motion picture projector and screen	Room darkened	1. Shows intricate operations in a clear, simple manner. 2. Special visual effects may be used.
4. Video tapes	1/2-inch or 3/4-inch reel or cassette video tapes	Videotape player and video or TV monitor	Room can remain lighted.	1. Records skills and real life situations for playback and review. 2. Can be used for immediate feedback.
5. Slides	35mm film mounted in 2x2-inch cardboard mounts	Slide projector and screen. Audio player unit with synchronizer if required.	Room darkened	1. Inexpensive to produce and reproduce. 2. Flexible sequencing. 3. Instructor controls pace of presentation. 4. May be synced to an audio accompaniment.
6. Filmstrips	35mm film in a continous strip	Filmstrip projector and screen. Audioplayer if filmstrip has sound.	Room darkened	1. Fixed sequence of presentation. 2. Economical production and reproduction 4. May be synced to an audiotape player.
7. Audiotapes	Coated plastic ribbon on reel or in cassette	Audiotape recorder/ player	Room can remain lighted	1. Economical sound recording and playback. 2. Easily changed.

TYPE	DESCRIPTION	EQUIPMENT REQUIRED	ROOM LIGHTING	ADVANTAGES
AUDIO-VISUAL PRESENTATION CATEGORY				
8. Display presentation easel.	Easel with pad of newsprint for use with markers May be coated to accept chalk and magnetized.	A supply of markers and chalk. Magnets if magnetized.	Normal room lighting	1. Completed newsprint sheets can be displayed on the room walls. 2. No time required to erase completed sheets. 3. Can be completed prior to class & covered.
TRAINING GRAPHICS CATEGORY				
9. Charts	Printed material which gives information in tabular format	Opaque projector and screen when it is desirable to project the graphic for the entire class. Otherwise, no equipment needed.	Room completely darkened when the opaque projector is used. Room can remain lighted at other times.	1. Easy to construct. 2. Inexpensive. 3. Can be drawn on chalkboard or VAP boards when projected. 4. Easily duplicated for trainee handouts. 5. Large classroom visuals are often produced on heavy paper or cloth.
10. Graphs	Symbolic drawing showing relationship or comparisons			
11. Diagram	Printed material showing chronological changes, distribution, components and flow.			
TRAINING DEVICES CATEGORY				
12. Models	Copy of the real object: enlarged or reduced size.	Usually no equipment is required other than the device itself.	Usually the room is kept well lighted to aid in seeing the device.	1. Clearly shows relationships among objects and parts. 2. Can eliminate non-essential elements for learning. 3. Appeals to multiple senses to aid learning. 4. Interest the trainee to develop greater depth of understanding. 5. Saves instructional time.
13. Mockups	Three-diamensional specialized working model.			
14. Cut-a-way	Object which has been sectioned to reveal internal structure.			
15. Actual device	Use of item of equipment or tool.	Actual item of equipment		

TYPE	DESCRIPTION	EQUIPMENT REQUIRED	ROOM LIGHTING	ADVANTAGES
PROGRAMMED MATERIALS CATEGORY				
16. Programmed Textbook (PI)	Printed text in one of several programmed formats.	None	Normal room lighting	1. Individualized self-study permits self-pacing to meet the individual trainee's learning style & pace. 2. Immediate feedback on responses provides the trainee with knowledge of errors due to misinformation. 3. Branching capability permits both remediation and advancement within the course & saves time. 4. Use of computer disc and video disc provides rapid random acess to course data.
17. Computer-Assisted Instruction (CAI)	Trainee-operated computer-controlled random-access print-based instruction.	Computer terminal with "main frame" computer or microcomputer		
18. Interactive Video Disk (IVD)	Trainee-operated computer-controlled random-access video-based instruction	Video-disc player, interface unit, microcomputer & color monitor		
SELF-PACED MATERIALS CATEGORY				
19. Self-study workbook (SSWB)	Printed workbook with information tests, etc. for self-study by trainee	Actual item of equipment or system being studied.	Normal lighting	Permits training of one trainee without the physical presence of an instructor, eg. on-board deployed ships or for background remediation.
20. On-the-job Training Handbook (OJT)	Instructor volume for supervisor. Trainee volume to supplement manuals, etc.			Self-paced instruction held on-board to learn tasks which cannot be learned in the formal classroom situation.
21. Technical Hands-on Training System Packet	Trainee training packet for self-study. Instructor guide packet.			Self-paced instruction on equipment, subsystem or system used outside of formal classroom situation.

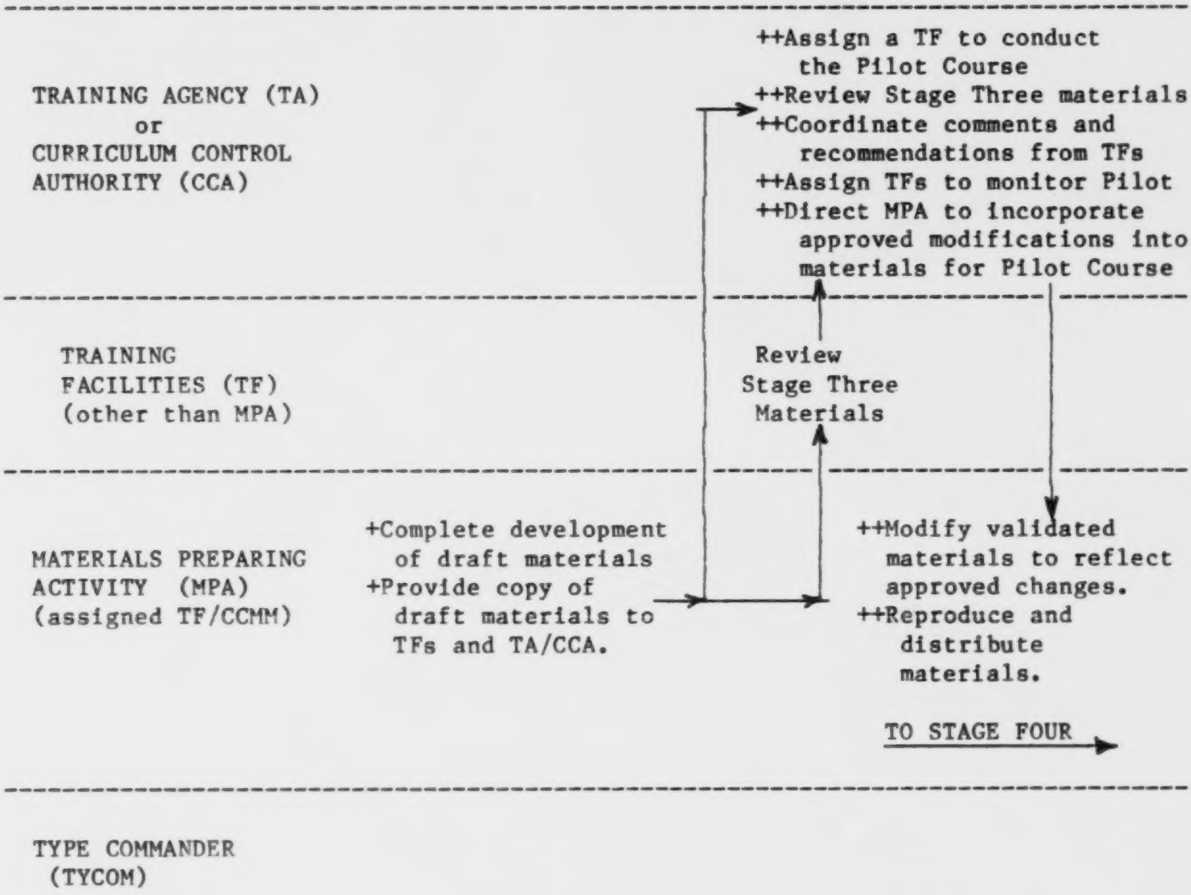
TYPE	DESCRIPTION	EQUIPMENT REQUIRED	ROOM LIGHTING	ADVANTAGES
TEAM TRAINING MATERIALS CATEGORY				
22. Exercise Controller Guide (ECG)	Printed guide for instructor to use in controlling an exercise, eg. Attack Center software.	As needed to perform the specific exercise	Appropriate to the equipment utilized.	1. Provides instructor with multiple exercises for team training. 2. Permits revision of or adding new exercises without the need to revise the IG for the
23. Instructor Utilization Handbook (IUH)	Printed guide to specific simulation equipment for instructors and training officers being used in a designated course.			1. Provides instructors with "user-friendly" guide to operation of simulation equipment needed in their course of instruction. 2. Provides students with a guide to their activities in the course.
24. Simulator Software Utilization Handbook(SSUH)	Printed guide for simulation system operators to test, evaluate, and correct deficiencies in simulator			1. Provides system operators with "user-friendly" descriptions and explanations of software construction and usage.

FIVE STAGES OF INSTRUCTIONAL MEDIA MATERIALS (IMM) DEVELOPMENT

(Reference: NAVEDTRA 38004A, Chapter 5, p. 25)

1. Listing of IMM to be developed for the course for review by CCA.
2. Cross-section of IMM to be developed. (This stage may be waived)
3. Complete development of all IMM in final draft form for review.
4. Validate IMM during "Pilot" course along with other curriculum materials.
5. Deliver master copies of IMM to the Course Curriculum Model Manager (CCMM).

FLOW DIAGRAM FOR CURRICULUM DEVELOPMENT - STAGE THREE


TRAINING AGENCY (TA) or CURRICULUM CONTROL AUTHORITY (CCA)
++Assign a TF to conduct the Pilot Course
++Review Stage Three materials
++Coordinate comments and recommendations from TFs
++Assign TFs to monitor Pilot
++Direct MPA to incorporate approved modifications into materials for Pilot Course
TRAINING FACILITIES (TF) (other than MPA)
Review Stage Three Materials
MATERIALS PREPARING ACTIVITY (MPA) (assigned TF/CCMM)
+Complete development of draft materials
+Provide copy of draft materials to TFs and TA/CCA.
++Modify validated materials to reflect approved changes.
++Reproduce and distribute materials.
TO STAGE FOUR
TYPE COMMANDER (TYCOM)

STAGE FOUR PILOT COURSE VALIDATION OUTLINE

1. Purpose of Conducting a Pilot Course.

   a. Assure the Curriculum Control Authority that the course "will work" through the process of validation
   b. Instruct other site instructors who will return to their training facilities to teach the course
   c. Gain input from other site instructors who also serve as subject matter experts
   d. Produce teachable "red line" edition of materials so that implementation can begin before final publication

5. Conducting the Pilot Course.

   a. Internal review of materials by all those present during the pilot course
   b. Instructor responsibilities include personalization of the course outlined in the instructor guide
   c. Trainee participation is observed by the monitors to see that the materials actual meet the learning objectives
   d. Monitor activities include:

      (1) Attendance at the pre-pilot conference
      (2) Be present for all lecture/lab sessions
      (3) Comment, as appropriate, on curriculum
      (4) Attend post-pilot conference

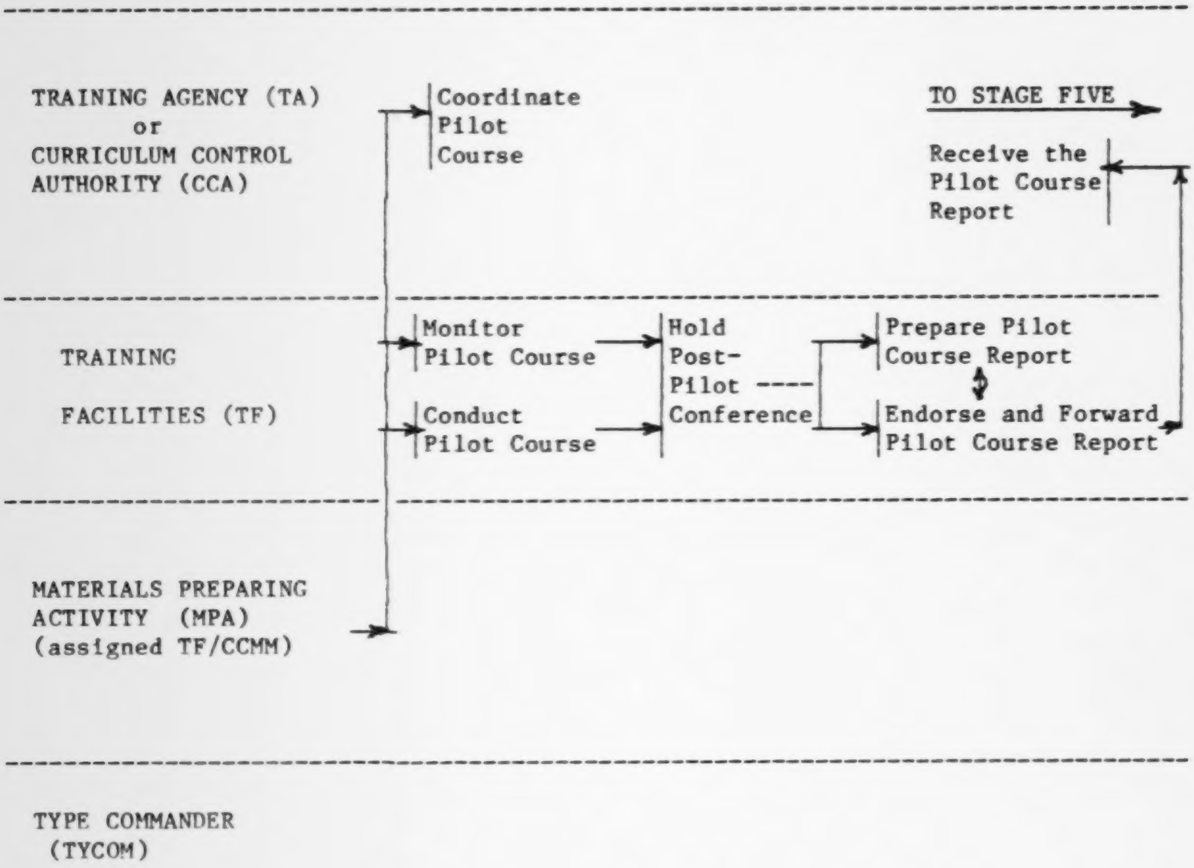
6. Pilot Course Final Report.

   a. Outline of the final report.
      (1) Administration, ie. time allocation
      (2) Curriculum Validation, ie. adequate materials
      (3) Technical Validation, ie. support of TLO
      (4) Redlined (annotated) copy of all materials
      (5) Minority report provisions.

   b. Report signed and sent to Curriculum Control Authority for approval/disapproval

   c. The Curriculum Control Authority either approves or disapproves the report as submitted

FLOW DIAGRAM FOR CURRICULUM DEVELOPMENT - STAGE FOUR


TRAINING AGENCY (TA) or CURRICULUM CONTROL AUTHORITY (CCA)
Coordinate Pilot Course
TO STAGE FIVE
Receive the Pilot Course Report
TRAINING FACILITIES (TF)
Monitor Pilot Course
Conduct Pilot Course
Hold Post-Pilot Conference
Prepare Pilot Course Report
Endorse and Forward Pilot Course Report
MATERIALS PREPARING ACTIVITY (MPA) (assigned TF/CCMM)
TYPE COMMANDER (TYCOM)

COURSE MANAGEMENT MATERIALS INFORMATION

1. There are two computer based management tools utilized by all Navy training commands for the purpose of information storage, retrieval and dissemination:

a. Catalog of Navy Training Courses (CANTRAC)

(1) A NAVEDTRA publication distributed on microfiche (Vol. II) and in hardcopy (Vols. I and III)

(2) A single alphabetic character in the first position of the Course Identification Number (CIN) identifies the command having Curriculum Control Authority, i.e., "A" = Chief of Naval Technical Training.

(3) The Course Curriculum Model Manager (CCMM) is assigned responsibility for maintaining specified courses for such items as budgeting for the distribution of curriculum materials and conducting curriculum reviews.

b. Navy Integrated Training Resources and Administration System (NITRAS)

(1) Computer reports (files) are used to manage and support courses.

(2) NITRAS contains the following files:

(a) Master Course Reference File (MCRF) which contains the course schedules, trainee statistics and class utilization data.

(b) Student Master File (SMF) which contains information on all personnel undergoing Navy training of 13 or more days.

(c) Training Summary File (TSF) which contains data on the number of trainees under Navy instruction and the "average on board" at each Navy training facility.

(d) Active Support File (ASF) which contains data on manpower authority and staff personnel assigned to each Navy training facility.

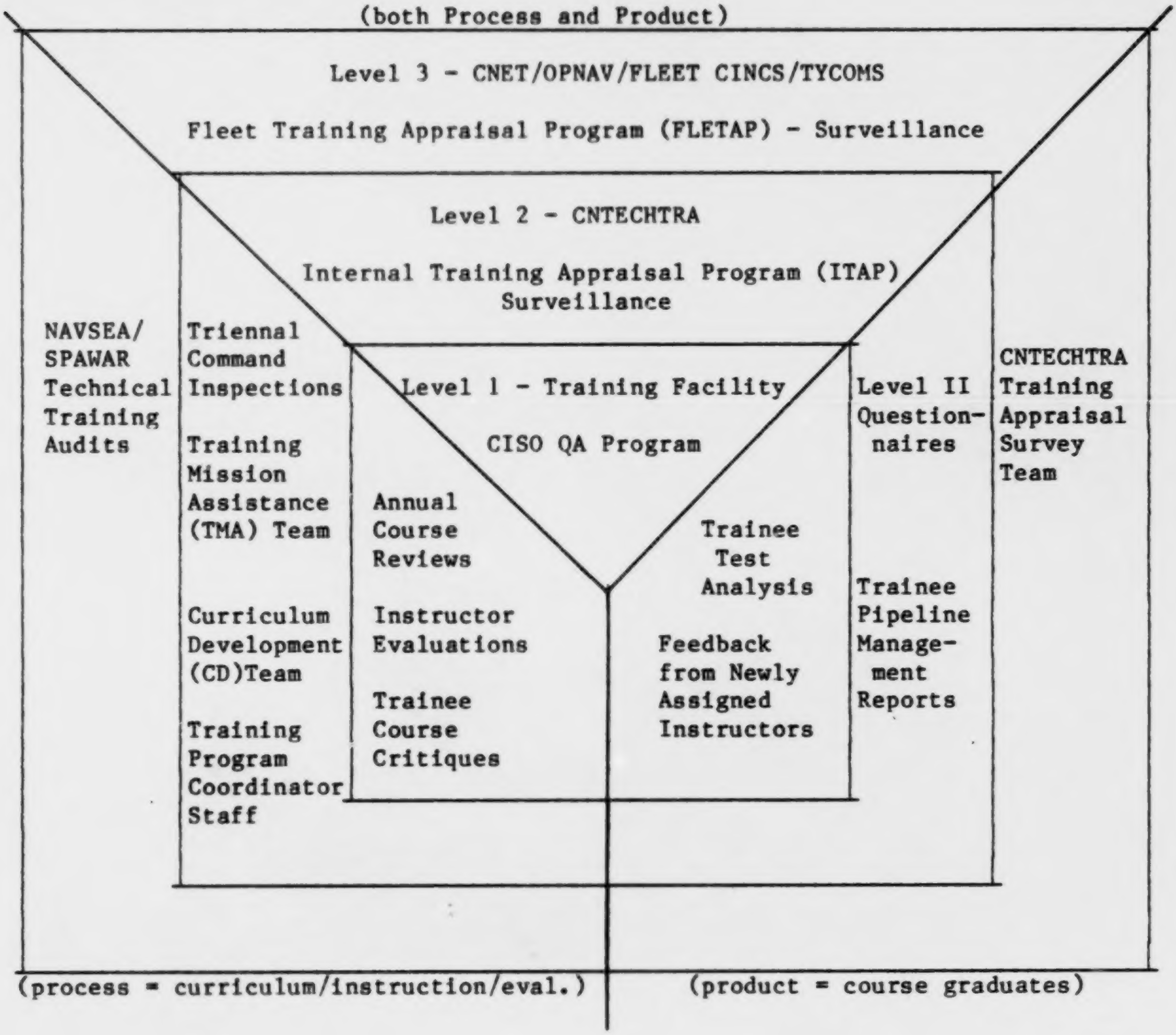
2. A third management tool is used by those Navy training facilities which utilize the NAVEDTRA 110A system of training.

a. Instructional Management Plan (IMP) which defines the procedures for administration and management of instruction. The following elements make up the IMP: Cover page, table of contents, forward, introduction, course management data, student flow management data, student flow diagram and the instructor qualification plan.

NAVY TRAINING APPRAISAL SYSTEM

1. Training commands are tasked to provide properly trained personnel to the fleet. To monitor this task the Chief of Naval Technical Training (CNTECHTRA) has established a Training Appraisal Program in order to assess the quality of training and assist in identifying and correcting any training deficiencies.

2. Navy training appraisal includes both the process of training and the product (course graduates) of training. Some parts of the program examine one of these two aspects while other parts include examination of both parts of the program. The diagram below defines three levels of appraisal and most of the specific parts of the program.


(both Process and Product)
Level 3 - CNET/OPNAV/FLEET CINCS/TYCOMS
Fleet Training Appraisal Program (FLETAP) - Surveillance
Level 2 - CNTECHTRA
Internal Training Appraisal Program (ITAP) Surveillance
NAVSEA/ SPAWAR Technical Training Audits
Triennal Command Inspections
Training Mission Assistance (TMA) Team
Curriculum Development (CD)Team
Training Program Coordinator Staff
Level 1 - Training Facility
CISO QA Program
Annual Course Reviews
Instructor Evaluations
Trainee Course Critiques
Trainee Test Analysis
Feedback from Newly Assigned Instructors
Level II Question-naires
Trainee Pipeline Manage-ment Reports
CNTECHTRA Training Appraisal Survey Team
(process = curriculum/instruction/eval.)
(product = course graduates)

CURRICULUM MODIFICATION MATRIX

Characteristics of Modifications	Three levels of curriculum modification		
	Interim Changes	Changes	Revisions
Recommended by:	Instructor	CCMM or TF CO	CCMM CO
Initiated by:	TF CO	CCMM CO	CCA
Modifications may include...	Pen & Ink notes Technical error corrections Urgent safety	TLO add/substract Change of sequence or instrl. method. Remove/insert pgs.	Change CLO,TLO &/ or course length Contents 50% +
Limitations on modifications:	No CLO, TLO or added resources No addition to course length	No CLO changes No additional resources or course length	No limitations Usually requires PILOT or other validation action
Incorporates these previous actions:	none	All interim - changes since the last change	All changes since the last revision
Alpha/Numeric Identification	Numeric: 2-1, 2-2, etc	Numeric: 1, 2, 3, etc	Alpha: A, B, C, etc.
Approval:			
Authority....	TF CO	CCMM CO	CCA
Format.......	specified form	specified form	letter of promulgation
Notification & Distribution Requirements	TF reports to CCMM in 5 days CCMM reports to all TFs within 10 days	CCMM distributes modified material to teaching TFs	CCMM distributes modified material to teaching TFs

Note: Technical Changes type of modification not included in the matrix.

CURRICULUM CHANGE PACKAGE:

1. Change identification - Numeric, eg. Change 1, Change 2, etc. used in sequence until next revision, eg. REV B CH-4
2. Change notice - specified format of letter giving instructions for incorporating changes, eg. remove/replace, delete, add pages. Includes justification.
3. Change pages - all modified pages of the curriculum that have been provided to replace existing pages or to be added.
4. Change materials - IMM (slides, transparencies, etc.) that have been modified or added to the course materials (also new MML pages, as needed)

Title:

Distance Learning via Satellite Begins with Analysis of the Users

Author:

Larry Bunting

DISTANCE LEARNING VIA SATELLITE
BEGINS WITH
ANALYSIS OF THE USERS

BY
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For years, education has been grasping at new technologies for the ideal educational tool. Many forms of instructional technology have come and gone in the last fifteen years. Some were acquired on the recommendation of equipment vendors. Others were purchased with the hope of being on the leading edge and, if successful, would mean a feather in the cap of the individual who thought of it. There are problems with acquiring instructional technology in this manner. The first example is almost always sold by a vendor who is usually biased with the opinion of his own product. In the second example, the individual has good intentions but there is invariably a good chance for failure.

Education via an educational satellite system is not exempt from these problems. This is why the first step in considering the adoption of this technology as an educational delivery system should be to better understand the individual groups (students, faculty, and administration) that will be using and served by such a system. The administration must be considered because of their problems with obtaining financial backing, curriculum adoption, and class scheduling. The faculty must be considered because they are the individuals that have to work with the technology and see that the system operates effectively. The students are the most affected since they are the recipients of the information and are the reason for the existence of the educational process.

In order to consider these three groups and their problems, research was conducted using a group of nineteen community colleges. The study looked at these three groups in order to get a better understanding of their attitudes, perceptions, and styles of teaching in regard to technology, facilities, and level of knowledge in various areas that were applied to distance learning via satellite.

In order to get a complete picture of the three groups, a determination was made as to what information should be gleaned from the participants that would give the appropriate information required for making decisions for a distance learning system.

Along with demographic information, the following were investigated and the results are reported.

1. **Learning Styles**: Students and faculty were not in total agreement as to what style was most commonly used at their institutions. Both indicated that the lecture method was the most dominant but faculty felt that the use of media materials was in greater usage than did the students. The majority of faculty had never tried teaching styles other than lecture with the use of media materials.

2. **Levels of Knowledge**: Administrators and faculty were questioned as to their knowledge in the areas of institutional facilities, alternative delivery systems, and satellite communications. In all instances, the administrators were the most knowledgeable. However, when it came to identifying various kinds of satellite terminology, neither the faculty nor administrators were very knowledgeable.

3. **How the Participants Felt About Educational Technology**: According to the three groups, educational technology is of great value in education and should continue to be steadily emphasized. Of the three groups surveyed, the administrators showed the greatest support for educational technology.

4. **How Individuals Felt About the Use of Educational Satellites**: Using satellites for distance learning was looked upon favorably by all three groups, but none were over-zealous about the idea. Of the three groups, the administrators were the most supportive.

When considering the use of satellites for international education, the administrators had mixed feelings regarding the future of satellites in international education.

5. **The Level of Administrative Support**: Administrators were very willing to support educational technology in general but were found to be spending very little for alternative forms of delivery. Even though some administrators were not budgeting any funds for alternative delivery systems, they still felt very strongly about its value for education.

6. **How Faculty Felt Toward Educational Technology in Relation to Their Teaching Styles**: Lecturing and using media materials was the dominant style of teaching. Those faculty whose teaching style was using lecture only were consistently less convinced of the benefits of technology in education.

Faculty who taught by using lecture and discussion or media believed that faculty should be doing more experimenting with educational technology.

All groups, even those that taught mainly by computer, felt that at times technology is moving too rapidly in our educational system.

7. **How Faculty Felt Toward Educational Technology in Relation to Their Curriculum**: Two groups of faculty that stood out were those in the Math-Science field and those teaching in the Social Science curriculum.

The Math-Science faculty were the most positive in regard to the use of technology in education, while the Social Science faculty did not see it as beneficial for education as did faculty in the other curriculums.

8. **How Students Felt Toward Educational Technology in Relation to Their Major Curriculums**: Two groups of students that stood out were those in the Math-Science field and those with a major in the Social Science curriculum.

The Math-Science students were the most positive in regard to the use of technology in education whereas the Social Science students did not see it as beneficial for education as did students in the other curriculums.

9. **How Faculty Felt Toward Educational Satellite Communications in Relation to Their Discipline**: All faculty represented in each of the various disciplines were very supportive of satellite education. Faculty teaching Technology courses showed the most favorable attitude toward education by satellite. Faculty who teach in the Health Science field were the least receptive to some of the ideas about what satellites are doing for education but over 80% felt that teaching with satellites is an exciting concept.

10. **How Students Felt About Educational Satellite Communications in Relation to Their Major Curriculum**: Students were middle-of-the-road when it came to indicating they would take a course via satellite. Technology students showed a very positive opinion relative to the use of satellites whereas Social Science students had the least favorable opinions. Math-Science students showed the least resistance in taking a course via satellite whereas the Communications students showed the most opposition.

Recommendations Based on the Results of the Study

Once the information was gathered for the above statements, a total picture of the students, faculty, and administrators became clear and the following recommendations were then proposed.

1. **Purchase Satellite Dish** - By doing this, it will be possible to demonstrate to the individuals involved as to what information is presently being sent from satellites at no expense to the downlink sites. This will help with individuals who expressed negative feelings toward the technology and at the same time take care of some of the hardware requirements for interactive instruction by satellite.

2. **Public Relations** - If the schools involved should decide to use satellites as a distance learning system, one of the first steps to be taken is that of informing the users. This informational program should include the viewing of existing satellite programming and an explanation of how interaction occurs.

The administrators, faculty, and students should be able to talk with individuals, using a satellite system, in order to obtain information which is not always covered in large group meetings or through informational literature.

3. **Budget** - Many schools did not report a budget for alternative delivery systems. A sharing of information should be undertaken with schools that are presently using satellites for curriculum support in order to discover all areas requiring funding and the possible hidden cost that might exist.

4. **Curriculum Selection** - As stated earlier, some curriculums will lend themselves more readily to satellite technology than will others. Each school should conduct an investigation to find out what these curriculums might be and then begin the use of satellite technology with the ones that show the least resistance. To not do this could prove to be counter-productive.

5. **Technology Integration** - If institutions decide to use an interactive satellite system, they should begin instructing faculty in the best ways of integrating the technology within their daily teaching. Doing this would help to decrease the possible apprehension experienced by those faculty that would be using satellites as part of their teaching. Too many times faculty are given the hardware and material for utilizing technology but are not instructed in how it is to be used.

6. **Services Available** - It was determined that many of the faculty were not aware of facilities and services related to educational technology that presently existed at their school. An on-going program to inform faculty about what is available should begin as soon as possible even though the actual use of satellites may not occur in the near future.

FURTHER STUDY

As stated earlier, this study was looking at a specific group of community colleges and the information applies specifically to them. Even though the findings apply to this group of colleges, the findings can be generalized for any educational setting.

The recommendations were drawn from the information gathered in this particular study. Other possible recommendations could have been made, however those listed are the ones believed to be the most crucial for identifying procedures for adopting and using an educational satellite system as a distance learning tool. Further study might be of value for identifying additional procedures to enhance the adoption and use of satellite technology.

One major concept that has been drawn from the study is to not let hardware determine the way courses will be taught. Involvement of the users from the initial investigative stages is essential when considering an educational satellite system as a form of instruction.

Title:

Can Interactive Video Overcome the "Couch Potato" Syndrome?

Authors:

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Can Interactive Video Overcome the "Couch Potato" Syndrome?

Current liteature abounds with the promises of inteactive video for revolutionaizing the instructional process. Although DeBloois (1982) contended that interactive video is an entirely new medium with characteristics quite unlike those of computers and video, recommendations for design and implementation of interactive video are often based on past televsion and computer research (see for example: Hannafin, Garhart, Rieber, & Phillips,1985).

Salomon (1983; 1984; Salomon & Leigh, 1984) conducted several influential studies on learning from television, and references to his findings are prevalent in the literature on interactive video. In the most frequently cited study, Salomon (1984) measured learners' preconceptions of the ease or difficulty of print and television, then the learners received either a print-based or video-based lesson. Upon completion of the lesson, learners completed a questionnaire on their perceptions of the amount of mental effort that they invested in the learning task, and were then given an achievement test. Salomon found that students perceived television as easier than print. Learners in the print condition reported investing more mental effort and had higher achievement scores than students who received the video lesson. Salomon concluded that the learners' preconception of television as a easy medium resulted in a decreased investment of mental effort and, consequently, lower achievement scores.

Several authors (Dalton,1986; Hannafin, et al, 1985; Schaffer and Hannafin,1986) have suggested that the active response required by interactive video lessons may overcome learners' preconceptions of television as a easy, passive medium, and result in increased mental effort and achievement. But although the results of Salomon's studies with linear video have been freely generalized to interactive video research and design, there is little research that has explicitly examined learners' preconceptions of interactive video.

A review of cognitive and motivational theory indicates that learners' scripts (Schank & Ableson, 1977), schemata, attributions (Weiner, 1979) and curiosity (Berlyne, 1960) may influence their preconceptions of a medium. Further examination of the literature suggests that learners' preconceptions may be influenced by their past experiences (Schank & Ableson, 1977), their perceptions of the learning task (Krendl & Watkins, 1983; Salomon & Leigh, 1984; Weiner, 1979), and the characteristics of the medium (Berlyne, 1960).

The characteristics of the medium can be manipulated easily in order to alter the learner's preconceptions of a mediated lesson and increase the mental effort that learners invest in processing the lesson. Several researchers (see for example: Dalton & Hannifin, 1987; Heestand, 1980; Lietke & Gall, 1985) have included practice questions in video-based materials and found that actively responding to embedded questions resulted in greater achievement scores than viewing a video-tape without practice questions. Anderson and Biddle (1975) reviewed the literature on practice questions in film, lecture, and text and concluded that practice questions seemed to faciliate the accquisition of both practiced and incidental information.

Although no researchers have included practice questions in video-based materials and examined the effects on students' perceptions of mental effort, several researchers (Britton, Piha, Davis, & Wehausen, 1978; Burton, Niles &

Lalik, 1986; Reynolds & Anderson, 1982) have included practice questions in text materials and found that practice questions may have increased the amount of mental effort used in processing the lesson.

Purpose of the Study

The purpose of this presentation is to summarize the results of a study that (a) investigated learners' preconceptions of interactive video (IV), instructional television (ITV), and television (TV), and (b) compared three treatment groups on learners' perceptions of invested mental effort and achievement on a test of recall and inference. The three treatments consisted of an IV lesson that included practice questions requiring an active response, an ITV lesson that included practice questions requiring a covert response, and a TV lesson that did not include practice questions. The relationship between learners' preconceptions and perceived mental effort was also investigated.

Research Hypotheses

The primary assumptions of the current study were based upon Salomon's (1983; 1984; Salomon & Leigh, 1984) findings that (a) television is perceived as easy, (b) there is a negative correlation between preconceptions of the ease of a medium and the amount of perceived mental effort, and (c) perceived mental effort is positively correlated with achievement on a test of inference items.

These primary assumptions were further developed based on a review of the related literature and the following expectations were generated: (a) Learners would perceive IV to be more difficult than ITV and TV, and learners would perceive ITV to be more difficult than TV; (b) learners would report expending greater mental effort in processing an IV lesson than in processing an ITV lesson or a TV lesson, and learners would report expending greater mental effort in processing an ITV lesson than in processing a TV lesson; (c) there would be a significant positive correlation between the perceived difficulty level of the video treatments and learners' self-reports of the amount of mental effort invested in processing the lesson using that medium; (d) learners who received the IV lesson would have higher scores on a posttest of inferences than learners who received the ITV lesson and the TV lesson, and learners who received the ITV lesson would have higher scores on a posttest of inferences than learners who received the TV lesson; (e) there would be no significant difference in the recall scores of learners who received an IV lesson, an ITV lesson, or a TV lesson; (f) there would be a significant positive correlation between learners' estimates of mental effort and achievement scores on a test of inference items.

Method

A posttest-only control group design was used for this study. The independent variable consisted of the video-based instructional materials with three levels (IV vs ITV vs TV). The students who received the IV treatment were provided with active practice, the students who received the ITV treatment were provided with covert practice, and the students who received the TV treatment were provided with no practice.

The dependent variables consisted of student ratings of perceived mental effort, recall scores, and inference scores. Information on student preconceptions of the difficulty of learning from IV, ITV, and TV was also collected for descriptive and correlational purposes.

It was assumed that random assignment controlled for differences in prior knowledge; however, a pretest was administered to a cohort group. The pretest confirmed that the target population did not have extensive prior knowledge of the content of the lesson: The mean score on a combined test of recall and inference items was 4.3 points out of a possible 60 points.

Participants

Seventy-eight undergraduate students were randomly selected and assigned to the three treatments; however, the final sample consisted of 23 students in the IV group, 25 students in the ITV group, and 23 students in the TV group due to attrition.

Instructional Materials

The instructional materials consisted of a TV lesson, an ITV lesson, and an IV lesson of approximately 20 minutes in length. Segments from an existing interactive video science unit on the topic of fission and fusion were modified for use in this study. The instructional strategy followed the events of instruction outlined by Gagné and Briggs (1979) and was similar for each treatment.

The manner in which the events of practice and feedback were presented in the three lessons constituted the primary difference among the three treatments. Conventional television programs typically do not provide practice and feedback on the concept presented in the program (Smith & Andrews, 1985); therefore, the TV treatment did not contain any form of practice and feedback. Although both the IV lesson and the ITV treatment included practice and feedback, learners were required to overtly respond to practice questions in the IV lesson, but were only given the opportunity to covertly respond to the practice questions in the ITV lesson.

Following the presentation of information for each objective (verbal information: recal1 and inference), the learners in the IV and ITV treatments were presented with a text screen that asked them to identify all statements that were true about the topic previously presented. In the IV treatment, students were required to touch all of the correct phrases and their responses were followed by "knowledge of response" feedback. In the ITV treatment, practice questions were followed by an extended pause and the students were expected to respond covertly. In both the IV and ITV treatments, each text screen that contained a practice question was followed by a text screen that provided the correct answers. The feedback in the IV lesson remained on the screen until the learners touched the screen to continue the presentation; the feedback in the ITV lesson was followed by an extended pause.

Collected Data

Preconceptions of difficulty.

A preconceptions questionnaire was administered immediately prior to the lesson to assess students' preconceptions of the difficulty of IV, ITV, and TV. The questions were identical to those used by Salomon (1984) to measure student preconceptions of print and television except for the subsitution of the words "interactive video", "instructional television", and "television" in place of "television" and "a book". To ensure that each of the participants interpreted the terms "interactive video", "instructional television", and "television" in the same manner, the terms were operationally defined.

Students were asked to rate their responses to questions such as " How easy would it be for you to learn to solve a math problem from interactive video?" on a 5-point Likert scale. One represented "very easy" and five represented "very difficult". There were three questions for each medium, and in accordance with Salomon's methodology, the scores on the three items for each medium were added together to result in an overall score for TV, an overall score for ITV, and an overall score for IV.

Although Salomon reported a Cronbach's alpha of .89 for his questionnaire, in the current study, the Cronbach's alpha was .75. However, the questionnaire was assumed to have an acceptable degree of internal consistency for the purposes of this study.

Mental effort. After completing the instructional materials, students were given a brief questionnaire which asked them to estimate the amount of mental effort that they had invested in processing the lesson. The questionnaire consisted of six questions that were derived by combining the questions that Salomon used in two studies (1983; 1984). Students were asked to rate their responses to questions such as "How hard did you concentrate while watching the lesson?". Students responded on a five point scale of effort with 1 representing "low" and 5 representing "high". Responses to each item were added together to provide a total score for each student. An analysis of the internal consistency of the instrument used in this study resulted in a Cronbach's alpha of .55.

Achievement measures. Cued recall and cued inference questions were included in the achievement measure. The questions required constructed responses that ranged in length from one sentence to several paragraphs. Student responses were scored as to the number of correct facts or ideas that they generated in response to the questions.

The recall items consisted of eight cued recall questions pertaining to explicitly presented verbal information. The test of inferences consisted of seven open-ended questions. Responses to the inference questions could include information that was explicitly stated in the lesson as well as inferences that connected ideas that were explicitly presented in the lesson. Responses that restated information that was explicitly presented in the lesson were coded as "recall"; responses that connected ideas that were stated in the lesson were coded as "inferences". Each student received a recall score that reflected the total number of facts that were correctly recalled in response to the recall and inference questions (maximum possible recall score = 45) and an inference score that reflected the total number of inferences generated in response to the inference questions (maximum possible inference score = 18).

Using the scoring key, an acceptable interrater reliability of .95 was achieved among the researcher and three graduate students in instructional technology.

Additional data collected. In addition to collecting data that was essential to the measurement of the dependent variables, students were asked to record the time when they began the lesson and when they completed the lesson. The time at which the student began the lesson was subtracted from the time at which the student ended the lesson to result in a lesson time score.

Procedures

Upon reporting to the research site, students were expected to complete the treatment independently and with a minimum of supervision. The experimental packet contained general instructions on how to proceed through the lesson, instructions on the operation of the equipment, and all treatment materials. First, the participants completed the preconceptions questionnaire, then they received instructions to proceed to the IV table, the ITV table or the TV table, depending on the student's assigned treatment. After students completed the lesson, they were instructed to complete the questionnaire on mental effort. After completing this questionnaire, the students were asked to complete the posttest of recall and inference items.

Results

The data were analyzed using several statistical tests of significance. Analysis of variance (ANOVA) was used to analyze the data among groupus on perceived mental effort ratings, recall scores, and inference scores. A repeated measures ANOVA was used to determine if there were significant differences among learners' preconceptions ratings for IV, ITV, and TV. This test was used to analyze the preconceptions data because ratings for each of the three media were obtained from each participant, thus the ratings were highly correlated. Following a finding of a significant F, Tukey's Honestly Significant Difference (HSD) test was used to determine the significant differences among individual group means. Correlations among scores on the measurement instruments were tested using a Pearson's r test of correlation.

Preconceptions of Difficulty

Out of a maximum possible difficulty rating of 15 for each medium, the mean rating for IV was 5.47, the mean rating for ITV was 6.21, and the mean rating for TV was 7.90.

A repeated measures ANOVA indicated that there was a significant difference in the learners' preconceptions of the difficulty of IV, ITV, and TV, $F(2,140) = 48.43$, $p < .01$. A Tukey's HSD post-hoc analysis ($p < .05$) of the data indicated that learners felt that it was significantly easier to learn from IV than from ITV and TV, and significantly easier to learn from ITV than from TV.

Perceived Mental Effort

Out of a maximum possible perceived mental effort rating of 30, the mean rating for IV was 20.56, the mean rating for ITV was 21.04, and the mean rating for TV was 20.00. ANOVA results indicated there were no significant differences in the learners' perceived mental effort ratings between treatments, $F(2,68) = .69$, $p = .51$.

Preconceptions of Difficulty and Perceived Mental Effort

Pearson's r test for correlation indicated that the correlation between the mean preconceptions ratings and mean perceived mental effort ratings did not reach significance for IV, $r = -.31$, ITV, $r = -.13$, or TV, $r = -.07$.

Inference Scores

The maximum possible inference score was 18 and the mean score for IV was 5.04, the mean score for ITV was 4.60, and the mean score for TV was 4.47. ANOVA results indicated that there were no significant differences between the mean inference scores of the three groups, $F(2,68) = .27$, $p = .76$; however the mean inference scores were in the predicted order (IV > ITV > TV).

Recall Scores

The maximum possible recall score was 45 and the mean score for IV was 20.4, the mean score for ITV was 18.6, and the mean score for TV was 15.5. ANOVA results indicated that there were significant differences between the mean recall scores of the three groups, $F(2,68) = 4.59$, $p = .01$. Tukey's HSD test for post-hoc analysis indicated that the learners who received the IV lesson recalled significantly more information from the lesson than learners who received the TV lesson. There was no significant difference between the mean recall scores of the learners who received the ITV lesson and the mean recall scores of the other two groups.

Mental Effort and Inference Scores

The Pearson's r test for correlation indicated there was a significant correlation between the mean perceived mental effort ratings and mean inference scores, $r = .27$, $p = .012$.

Post-hoc Analyses

Several post-hoc analyses were conducted in order to explore possible explanations for the results of the primary analyses.

Perceived mental effort ratings and recall scores. The results of the Pearson's r test of correlation revealed that there was a significant correlation between the learners' perceived mental effort ratings and their recall scores, $r = .33$, $p = .01$.

Lesson time. The data on lesson time were analyzed to determine if there were significant differences among treatment groups and to determine if there was a significant correlation between lesson time and inference scores or recall scores. ANOVA results indicated a significant difference between the three treatment groups in the amount of time that was required to complete the lesson, $F(2,68) = 8.66$, $p = .0004$. Further analysis using Tukey's test revealed that the IV ($M = 25.3$ minutes) and ITV ($M = 23.2$ minutes) groups took significantly longer to complete the lesson than the TV group ($M = 18.5$ minutes). However, there was not a significant correlation between reported lesson times and learners' recall scores, $r = .16$, or inference scores, $r = -0.02$.

Discussion

The purpose of this study was to investigate learners' preconceptions of the difficulty of interactive video (IV), instructional television (ITV), and television (TV) and to examine the effects of responding actively or covertly to practice questions embedded in video-based materials on perceived mental effort and achievement on a test of recall and inference items.

Preconceptions of Difficulty

This study was based on the premise that preconceptions of a medium influence the amount of mental effort that learners invest in processing a mediated lesson. The present study assessed learners' preconceptions of the difficulty of IV, ITV, and TV.

Although it was predicted that adult learners would perceive IV as more difficult than ITV and TV, and ITV as more difficult than TV, the results were in the opposite order. The learners perceived that it was significantly easier to learn from IV than from ITV and TV, and significantly easier to learn from ITV than from TV.

The differences between these findings and the results of Krendl's (1986) and Salomon's (1983, 1984; Salomon & Leigh, 1984) studies upon which the predictions were based may be due to the differences in the samples examined by the researchers. Salomon's samples consisted of public school students in grade six and Krendl's sample consisted of public school students in grades three through ten; however, the participants in the current study were undergraduate education majors from a select institution with stringent admission requirements. Due to the past academic successes of the learners in the sample examined in the current study, it is probable that they had more well-developed schemata relative to the learning process than the majority of students who are enrolled in public elementary or secondary schools.

Although the learners who participated in the current study perceived that it was easier to learn from interactive video than from television, this finding does not necessarily mean that the learners perceived interactive video as "easy". College students such as the ones included in this sample may be aware that an "easy" lesson is not necessarily easy to "learn from".

The pattern of means on the inference and recall test tended to support the learners' preconceptions of the difficulty of learning from the media utilized in this study: Although the differences among groups was not significant, the recall and inference scores tended to be higher for IV than for ITV and TV, and higher for ITV than for TV. In general, the more difficult it was perceived to be to learn from a medium, the lower the inference and recall scores of the learners who received a lesson using that medium.

These findings were opposite from the results reported by Salomon (1983; 1984; Salomon & Leigh, 1984): Salomon found that learners scored higher on a test of inference when leaning from a medium that was perceived as difficult (print) than from a medium that was perceived as easy (television).

Although information as to why the learners perceived one medium as easier or more difficult than another was not collected, the results indicate that the learners did perceive IV, ITV, and TV as very different in their ability to facilitate learning. Future research that examines the learners' rationale for rating one medium as easier or more difficult than another may provide information on the extent to which learners are aware of their own cognitive strategies for learning. In addition, studies that are similar to the current study should be conducted with other age groups and aptitude levels to determine to what extent preconceptions are a function of the age and aptitude of the learners.

Relationship of Preconceptions of Difficulty to Mental Effort

It was predicted that there would be a significant positive correlation between learners' preconceptions of the difficulty of a medium and their perceived mental effort ratings when learning from that medium; however, the predicated correlation did not occur.

The lack of a significant correlation between preconceptions of difficulty and perceived mental effort may have been due to the limitations of the measurement instruments. In particular, the low reliability of the perceived mental effort questionnaire may have masked potential results.

The lack of the predicted correlation also may have been due to the learners' interpretation of the questions on the two questionnaires. Whereas the preconceptions questionnaire was designed to assess the learners' general preconceptions of the difficulty of learning from a medium, the mental effort questionnaire was designed to assess the amount of mental effort that the learners perceived that they had invested in learning their specific assigned lesson. The preconceptions questionnaire required the learners to rate the difficulty of learning several tasks from each medium; the mental effort questionnaire required the learners to rate how hard they tried to understand the lesson, how hard they concentrated, how hard the lesson was to understand, how much the lesson made them think, how much they thought they could remember, and how much effort they used in comprehending the lesson. It is possible the amount of perceived effort required to understand, concentrate, think, and comprehend were not major factors that learners considered as they reported their preconceptions of the difficulty of learning from a medium.

Future researchers should use mental effort questionnaires and preconceptions questionnaires that are closely aligned in wording in order to provide insight on the role of preconceptions in the amount of mental effort invested in processing a lesson. For example, the perceived mental effort questionnaire used in this study asked the learners "How hard did you try to understand the lesson?"; a preconceptions questionnaire could be designed to access a similar construct by asking "How hard do you usually try to understand a television lesson?".

Perceived Mental Effort, Recall, and Inference

It was expected that altering the typical characteristics of video-based materials through the addition of practice questions requiring an overt (IV) or covert (ITV) response would overcome learners' preconceptions of TV as a passive medium requiring little mental effort; therefore, they would engage in actively processing the content, perceive that they were investing a large amount of mental effort, and achieve high scores on a test of inference items.

Although the manipulation of the characteristics of the medium did not affect the learners' perceived mental effort ratings or inference scores, it had a significant effect on the learners' recall scores. The data analyses indicated that the learners who received the IV lesson that required an active response recalled significantly more information from the lesson on a test of recall than learners who received the TV lesson that did not require a response. Actively responding to the practice questions in the IV lesson did not result in significantly greater recall scores than covertly responding to the questions in the ITV lesson, and covertly responding to the practice questions in the ITV lesson did not result in significantly greater recall scores than viewing the TV lesson without practice questions.

These results were not consistent with the predictions, but upon closer examination of the learning task, the results do not seem surprising. In the current study, the learners received practice questions at the verbal recall level, hence they were provided with direct practice toward the recall posttest. The practice questions were designed to ensure that the learners possessed the factual knowledge that was necessary for the generation of inferences. The learners were expected to connect the individual facts to create new inferences; however, they did not receive practice in the connection of the facts.

Several researchers (Heestand, 1985; Lietke & Gall, 1985) have found that factual postquestions facilitated the recall of the practiced information, but had no significant effect on the recall of information that was not practiced. Other researchers (Dalton & Hannafin, 1987; Lietke & Gall, 1985) have suggested that it is difficult to teach higher-level cognitive skills through the use of lower-level questioning strategies. It is possible that the recall practice questions may have caused the learners to focus on the rehearsal of the verbal information rather than on the elaboration of the content.

The fact that learners in the IV group reported significantly longer lesson times than the learners in the TV group may be offered as an alternative hypothesis to explain the results. But although there was a significant difference among the three treatments in the time spent on the lesson, there was not a significant correlation between reported lesson-time and recall scores. These results suggest that the differences in the recall scores of the IV group and the TV group were not entirely due to the greater amount of time spent on the lesson by the learners in the IV group.

The results of this study indicate that learners who are required to actively respond to practice questions that are embedded in a video-based lesson recall significantly more information from a video-based lesson than learners who are not provided with practice questions. The results also indicate that the inclusion of practice questions at the verbal recall level may not result in significant increases in the inferences generated in response to a video-based lesson.

However, the compressed range of the inference scores may have masked potential differences among the treatment groups. Out of 18 possible inferences, the mean of the IV group was 5.04, the mean of the ITV group was 4.60, and the mean of the TV group was 4.47. The type of practice question utilized in this study may have inhibited the generation of inferences, however, the compressed range of scores may also have been due to the difficulty of the scientific content for the non-science majors that participated in the current study.

Future researchers should continue to investigate the effects of practice questions with other types of practice questions, other types of objectives, and other groups of learners. Research that incorporates recall test items that are not directly matched to the practice questions may provide valuable insight as to whether increased recall scores are influenced by the direct rehearsal of the information that is included on the posttest or by a general review of the information that precedes the question. The effect of practice questions at higher-levels of cognitive processing seems to be an especially promising area for further research. It is possible that providing learners with practice questions at the inference level would result in the generation of a larger number of inferences than was observed in the current study. The effect of practice questions on the achievement of higher levels of learning outcomes such as intellectual skills or applications also seems to be a promising area for further research. Research with learners of different ages, aptitudes, and motivational levels than were used in the current study may strengthen the findings and increase the generalizability of the results.

Consistent with the predictions, a modest significant correlation was found between the learners' mean inference scores and mean perceived mental effort ratings. The post-hoc analyses indicated there was also a modest significant correlation between the learners' perceived mental effort ratings and their recall scores. As learners' perceived mental effort increased, their recall and inference scores also increased.

But although it was predicted that learners would perceive that they invested more mental effort in processing the IV lesson than in processing the ITV lesson and TV lesson, and that learners would perceive that they invested more mental effort in processing an ITV lesson than in processing a TV lesson, there was no significant difference between the three groups.

The prediction was based on the results of research studies (Britton, Piha, Davis, & Wehausen, 1978; Burton, Niles & Lalik, 1986; Reynolds & Anderson, 1982) that found the amount of cognitive capacity usage, as measured by a secondary task technique, increased when practice questions were embedded in text-based lessons. Although cognitive capacity usage and mental effort have been operationally defined in a similar manner by Salomon (1981), it is possible that the self-report measure used in the current study was not as sensitive to increases in mental processing as the secondary task measures that were used in the text-based studies, and in fact, may not have actually assessed the same cognitive processes.

The low reliability of the perceived mental effort questionnaire (Cronbach's alpha = .55) indicates that future researchers should use a different method of assessing perceived mental effort. The use of secondary task technique to assess cognitive capacity usage when learning from video-based materials may help determine if the inclusion of practice questions affects the amount of mental effort invested in processing video-based instruction and text-based instruction in a similar manner.

Conclusions

The conclusions of this study support the current practice of including practice questions requiring an active response in the design of interactive video instructional materials. The results suggest that responding actively to practice questions at the verbal recall level will increase the amount of information recalled from a video-based lesson that is designed to teach factual information at the verbal recall level. However, it appears that responding actively to practice questions at the verbal recall level will not increase the number of inferences generated in response to a video-based lesson. These findings suggest that video-based lessons designed to teach more than simple recall may need to include higher-level practice questions in order to increase the amount of information learned from the lesson. The results suggest that additional research is needed on the effects of actively and covertly responding to practice questions in video-based lessons.

Additional research also is needed on ways that different media are perceived. It has been suggested that preconceptions of media may vary depending in the age and aptitude of the learner.

Further research that examines learners' preconceptions of media and the ways that preconceptions can be altered to result in increased mental effort may be able to provide valuable information that may result in more effectively designed video-based lessons.

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Title:

Fourth Generation Instructional Design Model: An Elaboration on Authoring Activities

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Fourth Generation Instructional Design Model: An Elaboration on Authoring Activities

Instructional Design

Instruction is a process that involves both the planning of an environment where learning can take place and the delivery of information to the learner. How to improve learning in a planned environment has been a major concern of educational psychologists since the first formal research on classroom learning by Edward L. Thorndike (1969). Since Thorndike, learning in the classroom (or training) environment has been a focus of educational psychologists who, unlike experimental psychologists who have limited their study of learning to the laboratory, consider the complexity of factors that influence the effectiveness and efficiency of classroom instruction on improving learning.

Factors that contribute to the divergence in student learning include cognitive and affective variables, student knowledge, stimulus properties, delivery system (e.g., lecture, computer, video, etc.), management procedures (e.g., program control, learner control), instructional strategies, and evaluation methods.

Although educational psychologists, as well as other educators, have long dealt with these factors, it has only been in the past decade that they have investigated variables and conditions directly related to the planning of a total learning environment; that is, recognizing the interaction of multiple factors that go into designing and implementing instruction. Instructional systems design (ISD) is the term applied to this planning effort; it includes the processes of development, evaluation, and management. The ISD concept of development uses a scientific process that involves both the planning of an environment where learning can take place and the delivery of information to the learner.

Growth of this approach to instructional design has been facilitated by major inputs from fields of inquiry outside of education, such as computer science, management information sciences, and psychology; and within the field especially from instructional technology. Whenever possible, research and theory from these areas have been applied to appropriate phases in the updated ID model. Of these areas, computer science has had a major impact with such contributions as system design strategy variables (e.g., system architecture and software developments), structure of information (both as external information and internal representations), efficiency of design concepts (e.g., heuristic methods), and alternative learner control methods.

In the updated ID model the emphasize is on the basic principles of design using an iterative approach to development rather than a conventional algorithmic process model in which the output of one step becomes the input for the next. This is done for two reasons. First, the complexity of the ID process is a result of alternatives available for solving domain- specific learning problems. Thus, within phases the author has numerous options to be organized to fit the given situation. Second, the authoring activities can be independent of the decision making. Thus, in the design of an expert instructional design system, the knowledge base can be separate from an executive strategy system.

The principles of design in the updated ID model are based primarily upon learning and instructional research and theory and, just as importantly, upon applied development experience. It is one thing to talk and write about the instructional design process, and quite another to have actually done it. As a design science field, much like engineering, instructional design relies upon field experience for much of the "how to do it" components of its system. In this regard, the conglomerated authoring activities exhibit different degrees of theory-base and empirical base. For example, the analysis draws heavily on learning theory to set the conditions of learning and evaluation. In contrast, the development draws on field experience to define activities.

Another important trend toward a scientific approach to instructional design is the increased emphasis placed on the use of evaluation (Tennyson, 1978; also Tennyson paper AECT 1990). Although evaluation has always been part of the instructional design plan, it traditionally was relegated to the last step in the process. Even the most recent models (e.g., Merrill, 1983; Reigeluth, 1983) have only a minimal consideration of evaluation. The impetus for increased use of evaluation in development is part of a larger societal movement towards accountability in education and training. Following the guidelines presented by Tennyson's theory-based model (Tennyson, 1990), evaluation has become an integral part of the design system.

The various facets and combinations of the updated ID process (4th generation)--Analysis, Analysis-Design, Analysis-Maintenance, Design, Design-Development, Design-Development-Implement, Development-Implement, Development-Implement-Maintenance, Implement, Implement-Maintenance and Maintenance will be presented in terms of the authoring activities associated with each facet of the updated ID model. Figure one presents the updated ID model (fourth generation) as a dynamic processing model in reference to the elaboration of authoring activities (for further detail on updated ID model see Tennyson's presentation and paper).

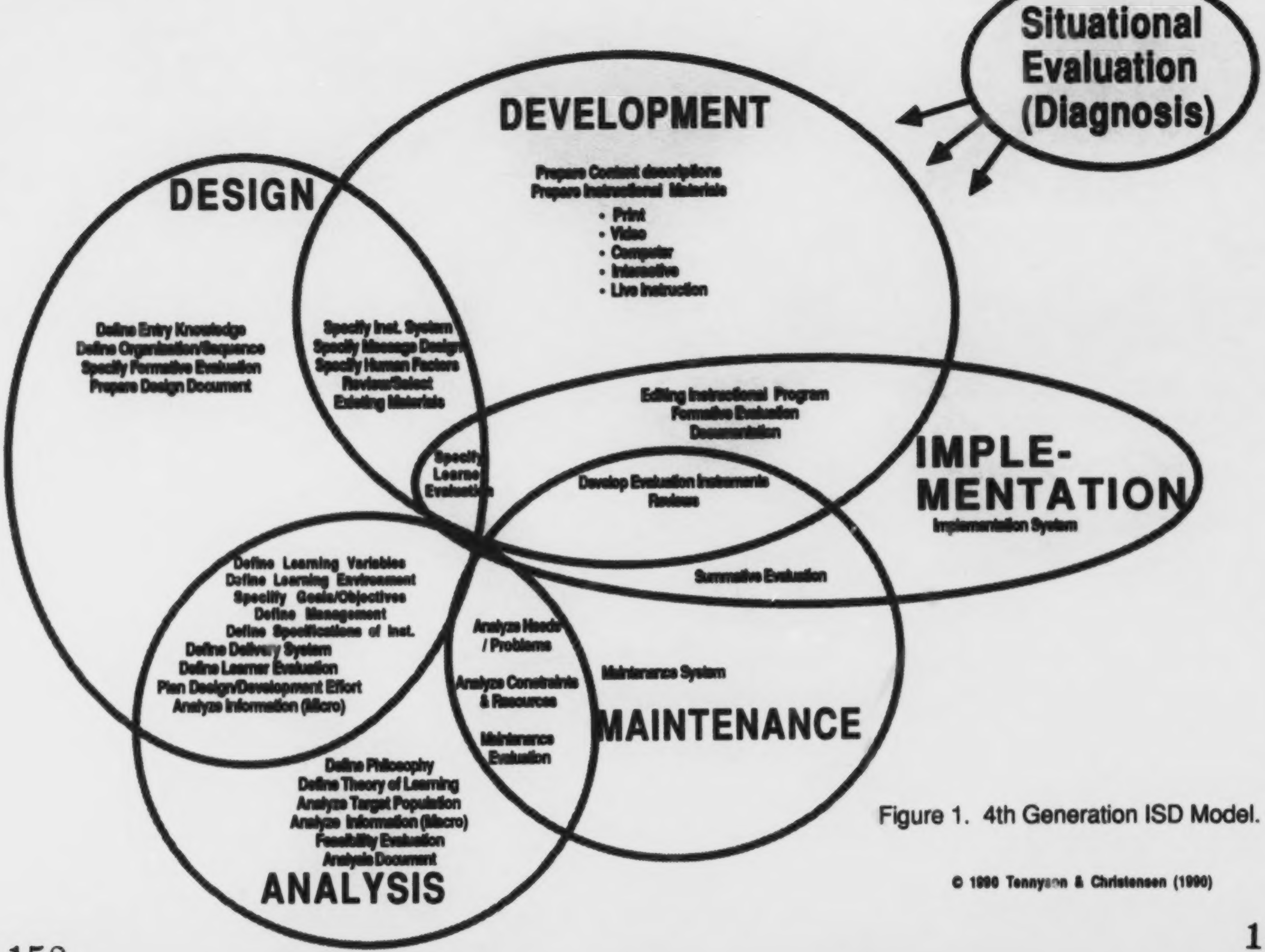
Situational
Evaluation
(Diagnosis)
DEVELOPMENT
Prepare Content descriptions
Prepare Instructional Materials
• Print
• Video
• Computer
• Interactive
• Live Instruction
DESIGN
Define Entry Knowledge
Define Organization/Sequence
Specify Formative Evaluation
Prepare Design Document
Specify Inst. System
Specify Message Design
Specify Human Factors
Review/Select
Existing Materials
Specify
Learner
Evaluation
Editing Instructional Program
Formative Evaluation
Documentation
IMPLE-
MENTATION
Implementation System
Develop Evaluation Instruments
Reviews
Summative Evaluation
Define Learning Variables
Define Learning Environment
Specify Goals/Objectives
Define Management
Define Specifications of Inst.
Define Delivery System
Define Learner Evaluation
Plan Design/Development Effort
Analyze Information (Micro)
Analyze Needs
/ Problems
Analyze Constraints
& Resources
Maintenance
Evaluation
Maintenance System
MAINTENANCE
Define Philosophy
Define Theory of Learning
Analyze Target Population
Analyze Information (Macro)
Feasibility Evaluation
Analysis Document
ANALYSIS

Figure 1. 4th Generation ISD Model.

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Analysis	Authoring Activities
Define philosophy and theory of learning conditions	These conditions influence each step in the ID process Thus, the generic steps are adjusted to account for the defined
Analyze target population	Determine learner characteristics: geographic location, age, ability, need for motivation, present skill levels, number of students Determine learner differences: cognitive style, aptitude, learning style, personality factors, motivation, perception
Feasibility evaluation	Validate the analysis process
Analyze document	Establish conditions of the learning environment conditions
Analysis-Design	
Define learning variables	Identify specific information to be learned
Define the learning environment	Establish scope and constraints of the ID process

Analysis-Design	**Authoring Activities**
Specify goals	State abstract descriptions of what knowledge is to be acquired (levels of knowledge—declarative, conceptual, and procedural)
Specify learning objectives	State objectives for learning program, specifying: desired conditions of learning (e.g. verbal information, intellectual skills, cognitive strategies, motor skills, attitudes)
Define management and delivery system	Establish role of computer in management of the learning environment Identify basic goals for computer delivery of instruction (and identify other alternative systems; e.g., interactive video)
Define specifications of instruction	Document conditions and specifications of program: length, structure, proportion presented by allowable media, target population description, definition of constraints, goals and information to be covered, levels of program intelligence within management and instructional system

Analysis-Design	**Authoring Activities**
Plan design and development effort	**Consider whether to: buy and use existing materials, modify an existing course, develop a new course, or discontinue development effort Estimate costs and resource requirements for each alternative**
Analyze information (micro)	**Knowledge engineering activities: Identify organization of information Establish knowledge base Determine schematic structure from knowledge base (referenced to conditions of learning) Determine schematic structure from semantic structure Determine semantic structure for content attribute characteristics**
Analysis-Maintenance	
Analyze learning needs and/or problem	Identify discrepancies between desired and actual learning and performance Determine consequences of learning and performance discrepancies
Define constraints restricting resolution of learning and performance discrepancies.	Identify the scope of the need/problem (i.e., curriculum, course, module and/or lesson)
Maintenance Evaluation	

Design	**Authoring Activities**
Define entry knowledge	Identify and determine learner entry knowledge and behaviors Determine learner (student) model: background knowledge, associative knowledge, prerequisite knowledge, prior knowledge
Define organization and sequence of information	Determine sequence of information through: a) course, b) module, c) lesson
Specify formative evaluation system	Outline strategy for validating learning materials
Prepare design document	Document all design decisions to guide development of prototype learning materials
Design-Development	
Specify instructional system	State Meta-instructional strategy
Specify meta-instructional strategies	Specify use of meta-instructional strategy variables: drill variables, placement of items, display time, label

Design-Development	**Authoring Activities**
	definition, context, best examples, expository examples, interrogatory examples, strategy operation, attribute elaboration
Specify mode of interaction	State level of system interaction: program initiative, mixed initiative
Specify screen management	Determine screen layout, positioning, sizing, etc.
Specify presentation modes	Select input/output modes: keyboard, positional, speech
Specify computer-based enhancements	Select computer-based enhancements: worked examples, display time, format of examples, amount of information, sequence, embedded refreshment & remediation
Specify methods of management	Design method of management per selected level of intelligence: flowchart, algorithmic, heuristic
Specify message design	Select display characteristics (e.g., graphics, text, color) Design screen layout

Design-Development	**Authoring Activities**
Specify human factors	**Design:** **menus, function key prompts, special helps glossaries Identify hardware configurations**
Review/select existing materials	**Select portions of existing materials appropriate for inclusion**
Define situational variables	**Identify existing materials, compare them with needs/problem Identify source manuals, subject matter experts, and resource people**
Design-Development- Implement	
Define conditions of learner assessment/evaluation	Determine the method(s) for assessing and evaluating learner knowledge acquisition (e.g., methods of diagnosis, error detection, error analysis)
Specify learner evaluation system	Determine on-task learning assessment and level of diagnosis (e.g. preventive, overlay, reactive, advisement, coaching) Determine use to be made of pretests, progress checks, and posttests Determine how assessments are to be administered (i.e., by computer or by paper)

Development	**Authoring Activities**
Prepare content narratives	Acquire and document subject matter content (i.e., knowledge base and schematic structure)
Prepare learning activity designs	Review learning activity designs and associated content for adherence to design and for accuracy and completeness
Develop learning activities	Employ strengths of medium Implement instructional strategies
Development-Implement	
Editing of learning program	Establish format and composition requirements Review all materials for grammar, style and consistency
Formative evaluation	Conduct one-on-one tryout of prototype materials Revise on the basis of one-on-one result Conduct simulation tryout Refine on the basis of simulation test Edit and produce Perform technical and mechanical review
Documentation	

Design Implement-Maintenance	**Authoring Activities**
Develop assessment instrument	Develop items appropriate for each objective and learning activity Develop items consistent with designed assessment system
Reviews	Subject matter experts review material for accuracy and completeness Designers review material to determine whether it meets requirements established in analysis and development phases
Implement	Reproduce materials Establish/modify support services Distribute materials Deliver instruction Collect data on learner performance and learner attitude
Implement-Maintenance	
Summative Evaluation	Analyze data Distribute report and recommendations Determine whether to make major revision (go to Analysis) or minor maintenance (go to Maintenance)

Maintenance	Authoring Activities
	Perform maintenance on learning activities and test items.

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Title:

Extrapolating from Richard E. Clark's Argument

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Extrapolating From Richard E. Clark's Argument

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A paper presented at the
1990 Annual Convention of the
Association for Educational Communication and Technology
Anaheim, California

1 February 1990

In recent years, researchers in our field have been engrossed in ongoing arguments about the value of research with media, research on media, and research on learning from media. Richard Clark, for example, has expended untold hours explaining the effects created by the gap between descriptive theory and applied research (Clark & Snow, 1975). Among other claims (Clark, 1983), Clark has concluded that ". . . media attributes are interchangeable and make no necessary psychological contribution to learning" (Clark, 1987). Based upon the available evidence, this, of course, is true. However, what Richard Clark did not tell us is that media attributes may make a sociological and/or physiological contribution to learning. He did not tell us this because, for many reasons, we did not ask the question. As a result, one is led to the conclusion that our narrowly focused questions may be a cause for concern (Clark, 1988).

Last year, Clark (1989) concluded that ". . . research quantity indicators do not support quality judgments." He went on to say that two major changes need to occur in the way that research is conducted in the future. First, ". . . more effort needs to be spent at the 'front end' or conceptualization stage of studies" and second, ". . . our studies need to stop emphasizing descriptive research and instead focus on prescriptive research designs and questions."

My purpose is threefold. One is to reiterate the distinctions between disciplines and applied fields of study and suggest that these distinctions should be evident in the descriptive/prescriptive research reports generated from each. A second is to impart my belief that replicating the theoretical and inquiry strategies of descriptive research may be debilitating applied research. A third is to discuss instruction in reality and the implications of a holistic research paradigm to study learning from instruction (The paradigm even includes the teacher/designer as an essential variable).

DISCIPLINES AND APPLIED FIELDS

Education is an applied field of study. Therefore, if education is an applied field of study, like medicine and law (not a discipline, like mathematics and chemistry), then so are the knowledge components that comprise it: instruction, curriculum, counseling, evaluation, and administration (Beauchamp, 1968).

In the classical sense, a discipline of knowledge includes research based upon mature theories that will encompass and/or correspond with both existing and new microtheories and macrotheories; the general concern is with delineating mature theories that must specify the dynamic causal relationships that exist within, between, and among all of the elements comprising the domain. Traditionally, the goal of basic research have been to generate new descriptive knowledge, if, for no other reason, the sake of knowing.

Generally, an applied field of study includes research based upon knowledge gleaned from one or more disciplines; the concern is with identifying eclectic systems, networks, paradigms, et cetera, to infer the ideal structure of functional, reality ladened, knowledge. The goal of applied research, in most cases, has been to generate new knowledge about designing, developing, implementing, managing, and/or evaluating the effective (natural science) and/or affective (social science) elements within the universe.

Therefore, the task of researchers and other professionals within an applied field of study is to translate and transform the "knowing what" descriptive knowledge generated in the disciplines to the "knowing how" prescriptive knowledge so necessary in an applied field of study. One must remember that the major difference between basic descriptive research and applied prescriptive research is reality. I mention the distinction only because it is so easy to lose sight of our purpose.

THE PROBLEM OF PURPOSE

It is my belief that at least part of the "purpose" problem, if it is generally conceived to be a problem, stems from the fact that many of the graduate programs of education (an applied field of study) have mirrored the theoretical and methodological inquiry strategies and techniques of science (a discipline). It follows, then, that our orientations about the theoretical constructs of research, in general, and methodology, in particular, have reflected and evolved from the "laboratory setting," where conditions and methods can usually be controlled, through statistics and/or randomization, to ignore potential dynamic causal relationships that exist within the domain of reality, but outside the domain of immediate concern or interest to the researcher. In reality, I am not implying that this model or the descriptive data that result from research conducted in a laboratory setting are good or bad; that question cannot be answered until we have incorporated and evaluated these data in our own applied research, in reality. Some would argue that this is an extension of the controversy between reductionists and naturalists (Guba, 1981; Magoon, 1977), while others will see it as a distinction between the professional research activities of those in a discipline and those in an applied field of study.

To summarize, the task of synthesizing descriptive data from the "root social sciences" (Clark, 1989) to form a usable paradigm for applied research is quite different than the task of employing, verbatim, the theoretical and methodological constructs of those same sciences. Certainly learner competence is a goal or end product that applied fields concerned with instructional theory hold in common with the root social sciences concerned with learning/cognitive theory, but the means of arriving at the end product is, or should be, different.

In the past, our commitment to the constructs imposed by a particular discipline has failed to produce the consistency, generality, and commonality needed for the development of a comprehensive paradigm for applied research on learning from instruction. Frustration with the limited yields from past research has prompted calls for new research directions. However, research without a theoretical domain may provide new directions which are no more beneficial as a guide to studying learning from instruction than the paths of the past. In the future, the relationship between learning/cognitive theory research and learning from instruction research must be reciprocal; each should serve, in part, to strengthen the other. Without some acknowledgement of the effective and affective processes involved in learning from instruction, applied research efforts will continue to produce extremely limited observations. Learning from instruction should be based, in part, upon the constructs of learning/cognitive theory, but instructional theory should not be confused with learning/cognitive theory.

INSTRUCTION IN REALITY

Perhaps the most pervasive problem with research on learning from instruction has been the lack of inclusiveness; our inattention to the totality of the instructional environment. Separately, we have covered several variables, usually more than one at a time, including learners, teachers, treatment characteristics, environmental or situational conditions, intrinsic and extrinsic motivation, media characteristics, and factors related to the instructional message or task. Research has been conducted from the individual researcher's conception of fundamental combinations of pertinent variables. Based upon what we have learned from our past research, it seems that one of the shortcomings has been our failure to consider certain variables and relationships that have been treated and evaluated by our colleagues in the disciplines and other applied fields. To illustrate, the learning/cognitive theorist does not focus on the specific elements of one essential component within a learning/cognitive model at the expense of the others. For, by themselves, the essential components are not theory: even though the within component elements play an integral part in defining a theoretical domain, in the final analysis, they often become subordinate to the relationships between and among component elements. This should also be the case with paradigms to study learning from instruction.

A PARADIGM TO STUDY LEARNING FROM INSTRUCTION

Although the paradigm described here has implications for instructional design, it is neither an instructional design paradigm nor a paradigm of instruction; rather, it is a research paradigm to study learning from instruction. The paradigm is based upon the presumption that there is both theoretical and intuitive commonality among the researchers and practitioners interested in learning from instruction. Therefore, for such a paradigm to be of value to all researchers within our applied field of study, it must be eclectic. It must be broad enough to include our psychological, sociological, and physiological experimental and naturalistic research interests, and dynamic enough to allow for the inclusion of various theories pertaining to how, when, where, and why learners become competent.

The clinical paradigm proposed here to study learning from instruction is based upon five essential variables of instruction: the learner, the teacher/designer, the task, the resources, and the instructional environment. It follows, then, that if learner competence is the ultimate product of the instructional environment, then an effective and affective instructional environment is the product of the interactions from within, between, and among the teacher/designer, the learner, the task, and the resources. The psychological, sociological, and physiological dimensions of the variables of instruction are used to further describe the distinctiveness of the static and dynamic attributes innately existing within, or designed into, each of the essential variables. Even though the proposed dimensions may not be mutually exclusive, this deficiency is minimized by viewing learning from instruction as a dynamic process. However, this should not be construed to mean that the dynamic and static attributes existing within, or designed into, the psychological, sociological, and physiological dimensions of the essential variables of instruction are not important indicators of potential interactions. They are, in fact, of great import to our efforts in diagnosing and prescribing the between and among relationships of the identified attributes associated with each of the variables of instruction.

On the one hand, learner competence is contingent upon the ability of the motivated learner to select, amplify, and/or manipulate the attributes of the other variables of instruction to form an environment that is *qualitatively* distinct. On the other hand, learner competence is contingent upon the ability of the teacher/designer to select, amplify, and/or manipulate the attributes of the other variables of instruction to form an environment that is *quantitatively* distinct. The implication of such within, between, and among dependence of the learner and the teacher/designer is that causal relationships within the instructional environment result from the abilities of the learner to integrate the functional relationships between and among the other variables in a schema that will result in a theoretically predictable performance. Functional relationships of the dynamic and static attributes within each variable and causal relationships between and among the variables of instruction and learner competence are best predicted from knowledge about the intermediary processes that occur within the learner as well as the potential effective and/or affective relationships that occur between and among all of the other variables of instruction. Hence, the objective form and subjective meaning of the learning task must yield both functional and causal distinctions in terms of the cognitive, affective, and/or psychomotor requirements of the learner.

Research proceeding from this conceptual level requires not only the examination of the essential variables of instruction (teacher/designer, learner, task, resources, and the instructional environment) and their attributes (psychological, sociological, and physiological), but of the essential intermediary processes (functional and causal relationships) as well. Together, these essential variables can serve as common denominators for a variety of research interests in applied fields such as instructional technology. Moreover, theoretical integrity would be established and/or advanced if these components were either implicit or explicit features of most, if not all, research paradigms.

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Title:

Paper Versus CRT - Are Reading Rate and Comprehension Affected?

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ABSTRACT

In the past century, much research has addressed the legibility of text in print. Sanford (1888), Griffing and Franz (1896) and Tinker (1963) have contributed to this body of knowledge. Studies were performed to determine the best length of line, color, and line spacing, etc. More recently, researchers have found that reading rate is adversely affected by the legibility of the electronic screen text. Most legibility studies used adult subjects.

The only reading from a computer screen studies involving junior high school students were by Feldmann and Fish (1987, 1988). The major focus of the study, was to determine if reading from the computer screen affected junior high school students' comprehension. Additionally, the study questioned whether reading rates were affected by the legibility of electronic screen text.

The present study investigated differences in reading rate and comprehension scores of eighth grade students on a cloze reading exercise involving the reading of a cloze passage from ten different modes text of presentation. The study was designed to compare reading rate and comprehension scores of junior high students reading from paper copy or computer screen. In addition, the study was designed to determine optimal electronic screen text presentation modes, involving line length, background and foreground color, and contrast ratio.

Two one-way ANCOVAs were used to analyze the data. One ANCOVA analyzed reading rate while the other analyzed the comprehension scores. The ANCOVA results indicated that there were no statistically significant differences in reading rate or comprehension score for any of the ten groups.

The findings of no differences in reading speed from electronic screens to paper conflicts with most of the findings on adult reading rate research (Gould & Grischkowsky, 1984, 1986; Hathaway, 1984). Reasons accounting for the difference in findings may be: (a) the reading of the adult subjects was superior to the eighth grade students; (b) the nature of the reading materials, proofreading as opposed to a cloze passage; and (c) the focus on groups of students rather than the individualized treatment of adults. This would suggest that reading level might be a factor affecting reading rate from electronic screens or paper.

The finding of no difference in comprehension was consistent with previous studies. Thus, the ability of adults or eighth grade students, to comprehend text does not appear to be impaired by the

decreased legibility of computer screens. Although the reading rate of adults seems to be effected by the legibility of computer screens, eighth grade students' reading rates do not appear to be adversely affected.

Paper Versus CRT - Are Reading Rate and Comprehension Affected?

Computers and electronic screens have become integral parts of American society. Office workers, engineers, scientists, designers, writers, accountants, and many others spend long hours in front of electronic screens. Often, the amount of text presented on the screen is considerable.

Student computer usage in schools has increased rapidly. There are approximately 52 thousand computers, for instructional purposes, in approximately 48 percent of the public school districts (Becker, 1986; Niman, 1987). Many states now require students to take computer literacy classes. Because of the great influx of computers into schools, the time has come to assess the impact of the electronic screen on reading performance in a school setting.

Reading Performance

There is considerable evidence that electronic screens negatively impact reading performance when presenting text. Adults read more slowly from electronic screens (Gould, Alfaro, Barnes, Finn, Grischkowsky, & Minuto, 1987; Gould, Alfaro, Finn, Haupt, & Minuto, 1987; Gould & Grischkowsky, 1984, 1986; Hansen, Doring, & Whitlock, 1978; Hathaway, 1984; Kruk & Muter, 1984; Muter, Latremouille, Treurniet, & Beam, 1982). A few studies (Gould & Grischkousky, 1984, 1986; Muter et al., 1982) have indicated that reading rate decreased by as much as 20 to 30 percent when the computer-based electronic screen was the mode of text presentation.

Text Legibility

Text legibility research defines those features that affect electronic screen text legibility. According to Tinker (1963), a foremost scholar in printed text legibility, reading speed is critically dependent upon text legibility. Legibility, according to Tinker (1963, p. 8),

> ...deals with the coordination of those typographical factors inherent in letters and other symbols, words, and connected textual material which affect ease and speed of reading.

The factors associated with legibility include: the size of the print, the shape of the font, the illumination of the reading environment, the color and quality of the paper, and the distance between letters and between lines of print. Daniel (1985, p. 4) in referring to electronic screens stated, "the term 'legibility' denotes how specific physical characteristics of a display effect

[sic] visual fatigue, reading speed, and ultimately comprehension".

Studies of printed text legibility date back to Sanford (1888) and Griffing and Franz (1896). Huey (1968) summarized many text legibility studies and made recommendations about the optimum text presentation. The conclusions from Huey (1968) included: (a) the type should be no smaller than 1.5 mm or 6 points, (b) the optimal line length should be between 90 and 100 mm or about 60 characters per line, (c) the best color paper is white, and (d) the use of double spaced text or additional leading, that is more space between lines of print improves legibility. Tinker (1963) also found that the curvature of printed material, like that found in books with narrow "gutters", reduced reading speed.

Finally, Tinker (1963) investigated color combinations of print and paper. Tinker (1963) observed that black print on a white background, "yielded the most rapid reading" (p. 146). But, other color combinations were almost as effective: green on white, blue on white, and black on yellow. All other color combinations retarded speed of reading considerably.

Computer Screen Legibility

During the 1970s and 1980s, researchers investigated electronic screen legibility. Hoover (1977) compared reading performance with single and double spaced computer text. No statistically significant differences were found in reading rate although the subjects indicated that they had more trouble reading single spaced text (Hoover, 1977).

Kruk and Muter (1984) performed a series of three experiments to determine if it was feasible to read continuous text from an electronic screen. They concluded that it was feasible, but that reading speed was slowed by approximately 25 percent. They later concluded that this speed deficit could be decreased to 10.9 percent through the use of double spacing.

Other studies investigated reading rate using printed text and computer screen text. Hansen et al. (1978) had college students take a reading test on computer-based electronic screens and on paper. They found that students read more slowly on computer screens. Kak (1981) performed a similar study with a standardized, timed reading test. Kak's results indicated no statistically significant differences in reading scores when only completed parts of the test were graded. However, a four percent slower reading speed was reported for students taking the test on computer. Kak (1981) concluded "that legibility criteria may be excessively strict when applied to tasks involving reading of connected prose text" (p. 139).

Switchenko (1984) conducted a study involving adult subjects in a comprehension reading task. Subjects read two short articles which differed in degree of difficulty. Subject then answered comprehension questions. Switchenko found no significant differences in reading speed or comprehension scores from computer or paper. Switchenko (1984) argued that studies which found a difference in reading speed did not have adequate and proper experimental controls. Gould et al. (1987) concluded that adults could read as fast from a computer screen as they could read from paper. In the experiment, the fonts appeared similar in the two media. An extremely high resolution computer displays with black font on a white background was used. Thus, there is some controversy whether or not reading speed is decreased on a computer screen. An important note that needs to be made is that all of these studies used adults. To this point, there are only two studies (Feldmann & Fish, 1987a, 1987b) involving school aged children assessing reading rate and comprehension differences with paper and computer screens.

Statement of the Problem

A survey of available literature on electronic screen legibility uncovered only one related study involving junior high age students (Feldmann & Fish, 1987b). The students in the study were high ability eighth grade students and no statistically significant difference in reading comprehension was found between paper and computer-based electronic screen media. Other electronic screen legibility studies were generally conducted in the workplace with small samples of convenient adult subjects.

Other questions also need to be addressed. If indeed, junior high students do read more slowly from electronic screens as adults seem to, are there easily controlled factors which might improve the legibility of print on electronic screens?

The present study investigated if there were differences in reading rate scores of eighth grade junior high students on a cloze reading comprehension task involving the reading of text from several different modes of presentation. The following modes of presentation were studies:

1. An electronic screen with white text on black background utilizing a line length of 60 characters.
2. An electronic screen with white text on a black background utilizing a line length of 80 characters.
3. An electronic screen with black text on white background utilizing a line length of 60 characters.
4. An electronic screen with black text on white background utilizing a line length of 80 characters.

5. An electronic screen with black text on a light blue background utilizing a line length of 60 characters.
6. An electronic screen with black text on a light blue background utilizing a line length of 80 characters.
7. An electronic screen with white text on a light blue background utilizing a line length of 60 characters.
8. An electronic screen with white text on a light blue background utilizing a line length of 80 characters.
9. White paper with black IBM PC Junior matching font printed on a dot matrix printer with a line length of 60 characters.
10. White paper with black Courier 10 font printed on a laser printer with a line length of 60 characters.

The two research questions addressed in this study were:

1. Is there a difference in eighth grade students' reading rate on a reading comprehension task among groups performing the task using several different modes of presentation?

2. Is there a difference in eighth grade student's comprehension score on the reading comprehension task among groups performing the task using several different modes of presentation?

Method

Three hundred junior high school students in computer literacy classes, in seven schools from a large suburban school system, were involved in this study. The subjects were randomly placed into one of 10 treatment groups. The subjects completed a cloze reading passage. The first and last sentences of the passage were left intact, but every fifth word in the main body of the passage was deleted. The passage had fifty missing words. The students read the passage, decided which words were missing, and wrote these words on an answer sheet. The time, in minutes and seconds, taken to complete the exercise was measured by the investigator using a stop watch. The time to complete the passage was used as the subject's reading rate. The passages were subsequently scored, and this score was used as the subject's comprehension measure. Subjects all read the same passage, but the passage was presented in one of the 10 different text presentation modes. This design allowed comparisons to be made among the means of the various treatment groups.

In order to allow the subjects to become familiar with the cloze procedure, subjects participated in a 20 minute practice session one day before the data collection. The practice session also enabled the subjects to practice using the arrow keys on the computer to scroll text forward and backward on the screen. Actual collection of data took one class period. Administration of the cloze passage took approximately 30 to 35 minutes. Collection of materials took approximately 5 minutes with no more than 45 to 50 minutes was needed to collect the data. Class periods in the schools participating in the study were 55 minutes in length.

The students were told that their reading would be timed, but that reading time was not as important as being accurate. Students were asked to raise their hand when they completed the exercise. A stop watch was used to measure the time it took students to complete the cloze passage. When all students had completed the exercise, all materials were collected.

Instrumentation

The De Santi Cloze Reading Inventory was used as the dependent variable. The cloze procedure may be used to determine if students are able to comprehend certain material. Three levels are used in traditional measures of comprehension for cloze passages: independent, instructional, and frustration. Fifty responses are possible in the passage and the number of correct responses is multiplied by .02 to derive a percentage.

"The inventory was field tested 3,456 times with a total of 864 students drawn from two school systems (De Santi, Casbergue, & Sullivan, 1986, p. 131). The correlated concurrent and predictive validity for eighth grade cloze passages with CTBS total reading scores was found to be statistically significant at the .001 level.

The inventory has single-rater and inter-rater reliability. De Santi and Sullivan (1985) determined single-rater reliability; the mean reliability of the Traditional Comprehension interpretation value was determined to be .96. This was also the mean value for the inter-rater reliability (De Santi & Sullivan, 1985).

For the purposes of this study, The De Santi Cloze Reading Inventory was converted to the eight different computer presentation modes. Additionally, two different paper presentations modes were created. The first paper version (group 9) was created using the ChiWriter (1988) software package to create a font similar to the font used on the IBM PC Junior computer screen. The second paper version (group 10) was printed on a laser printer with Courier 10 font. These modifications were made to place better controls on the presentation modes.

Results

The results of the two research questions are presented.

1. Is there a difference in eighth grade students' reading rate on a reading comprehension task among groups performing the task using several different modes of presentation?

To test this first hypotheses, a balanced one way Analysis of Covariance (ANCOVA) statistical procedure was performed using SPSSPC. The reading rate of subjects on the cloze reading task was the dependent variable while the covariate was the normal curve equivalence (NCE) score on the Total Reading subtest of the CTBS. Table 1 presents a summary of descriptive statistics for the CTBS covariate scores. The highest score for the sample test was 99 and the lowest score was 3.

INSERT TABLE 1 ABOUT HERE

Subjects were randomly assigned by the use of a random number table to 10 text presentation groups. The mean reading rate for each group was determined. Table 2 presents the mean and standard deviation for the reading rate of the 10 groups.

INSERT TABLE 2 ABOUT HERE

No statistically significant differences were found at the .05 level in the omnibus hypothesis among the means. Additionally, the effect size was low (4.5%), thus the results were also not educationally significant. Table 3 presents the ANCOVA summary table for reading rate. The null hypothesis was not rejected; therefore, no post hoc tests were performed. This finding contradicts most research studies (Granaas, McKay, Laham, Hurt, & Juola, 1984; Heppner, Anderson, Farstrup, & Weiderman, 1985).

INSERT TABLE 3 ABOUT HERE

When performing a cloze reading exercise, the reading rate of eighth grade students was not statistically or educationally significant when reading from paper or computer. Although no statistical differences were found with the ANCOVAs, students with independent level reading ability did read 27 percent slower from electronic screens than paper.

2. Is there a difference in eighth grade student's comprehension score on the reading comprehension task among groups performing the task using several different modes of presentation?

To test the second null hypothesis, a balanced one way ANCOVA statistical procedure was performed using the comprehension of subjects on the cloze reading task as the dependent variable. The covariate was the normal curve equivalence score (NCE) on the Total Reading subtest of the CTBS. A mean comprehension score was determined for each group. Table 2 presents the descriptive statistics for the comprehension scores.

No statistically significant differences were found among the means on the omnibus hypothesis. Table 4 presents the ANCOVA summary table for comprehension scores. The null hypothesis was not rejected and thus, no post hoc tests were performed.

Students' comprehension scores did not appear to differ for any of the groups tested. This finding was in agreement with the vast majority of previous studies which tested comprehension in various text modes (Feldmann & Fish, 1987a, 1987b, 1988; Gould et al., 1987; Gould & Grischkowsky, 1984, 1986; Kruk & Muter, 1984; Kak, 1981; Switchenko, 1984).

INSERT TABLE 4 ABOUT HERE

Conclusions

The findings of no differences in reading speed from electronic screens to paper conflicts with most of the findings on adult reading rate research (Gould et al., 1987; Gould et al., 1987; Gould & Grischkowsky, 1984, 1986; Hansen et al., 1978; Hathaway, 1984; Kruk & Muter, 1984). Reasons accounting for the difference in findings may be: (a) the reading of the adult subjects was superior to the eighth grade students; (b) the nature of the reading materials, proofreading as opposed to a cloze passage; and (c) the focus on groups of students rather than the individualized treatment of the adults. This would suggest that reading level might be a factor affecting reading rate from electronic screens or paper.

The finding of no difference in comprehension was consistent with previous studies. Thus, the ability to comprehend text is not necessarily a function of legibility but reading level. The reading rate is affected by legibility. Thus, a reader would reduce his reading rate in order to maintain comprehension.

Summary

There was no statistically significant difference in eighth grade students reading from electronic screen or paper. The length of lines or the medium seemed to make no difference. Thus, for a 30 minute reading task, the medium did not make a marked difference in either the reading rate or comprehension.

More research needs to be performed with school aged children to better identify if different ability groups of students are more or less affected by the presentation mode of text. Research should also be performed to investigate if the reading rate and/or comprehension would deteriorate given longer reading spans. Finally, other computers besides the IBM PC Junior should be used to determine if particular computers, and the generated font, affects reading rate and/or comprehension.

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Table 1

Means and Standard Deviations for CTBS Total Reading NCEs by Group

Group	Mean	SD
1	45.63	19.70
2	56.93	21.46
3	55.03	17.73
4	52.40	17.39
5	55.13	23.88
6	55.77	19.10
7	57.50	22.33
8	52.23	21.99
9	49.70	18.68
10	51.47	23.10
Total	54.08	20.48

Note. Each group contained an _N_ of 30.

Table 2

Descriptive Statistics by Group on Reading Rate and Comprehension

	Reading Rate		Comprehension	
Group	Mean	SD	Mean	SD
1	12.28	3.84	49.80	9.00
2	14.10	5.57	50.40	8.43
3	13.36	4.34	50.87	8.55
4	13.13	3.30	45.53	7.25
5	12.90	3.66	50.73	7.17
6	12.16	4.03	48.53	9.67
7	13.86	5.30	48.47	9.77
8	13.02	3.68	46.80	12.29
9	11.96	4.05	50.13	8.40
10	12.78	6.05	48.13	10.53
Total	12.96	4.45	48.94	9.28

Note. Reading rate was measured in minutes.
Note. Each group contained an _N_ of 30.

Table 3

ANCOVA Summary Table for the Effect of Text Mode Presentation on Reading Rate

Source	SS	*df*	MS	*F*	r^2
Covariate NCE	1154.78	1	1154.78	72.96	.195
Main Effect Group	205.31	9	22.81	1.44	.035
Residual	4574.27	289	15.83		

Table 4

ANCOVA Summary Table for the Effect of Text Mode Presentation on Comprehension

Source	SS	*df*	MS	*F*	r^2
Covariate NCE	10441.34	1	10441.34	207.37	.416
Main Effect Group	78.10	9	8.68	.17	.003
Residual	14551.49	289	50.35		

Title:

Unthinking Educational Technology

Author:

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Unthinking Educational Technology

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> *Feminist scholarship and feminist activism proceed not through a sterile, planar dialectic of thesis, analysis, synthesis, but through a dynamic process of unthinking, rethinking, energizing, and transforming. At its best, feminism creates new life forms out of experiences as common as seawater and insights as electrifying as lightening. (Bush, 1983, p. 152)*

The purpose of this paper is to begin a feminist unthinking-rethinking-energizing-transforming of the project (phenomenon, activitiy, effects, etc.) we call "educational technology." As Corlann Gee (Corky) Bush indicates in the statement above, the activity of unthinking requires that we resist the traditional, habitual, and for many of us almost automatic, tendency to begin an examination of "educational technology" (the thesis) by breaking it into constituent parts, "education" and "technology", analyzing these separately, and rationalizing their synthesis. An unthinking of Educational Technology requires that we unthink this procedure which is inherent, not only in our instructional design models, but also in many of our critiques (e.g., Nunan, 1983), and in those studies which attempt to relate specific technologies to educational goals. Every analysis based upon the independent listing and correlation of objectives with media and methods has the effects of reifying some set of educational goals or objectives and of validating some set of media, materials, and hardware or software technologies as the logical completion of the reified goals.

Such an analysis fragments the domain of discourse, changing its focus from educational technology *per se* to a set of concerns about the elements identified in the analysis. Many of these are relevant to the interests of women; for example, the question of whether computers are less appealing and effective for females than for males is of some importance to women seeking equal opportunities to learn specific content, but it begs the question of what we mean by "effective." Moreover, each analysis invites further analysis and further fragmentation; having identified a specific medium or category of materials, we can ask more specific questions: how is sexism replicated in that medium? how might the sexist elements identified be eliminated?

The point is that in this type of examination we are deeply engaged in **thinking educational technology**; at each step of the analytic procedure, the previous, more inclusive, construct is accepted and implicitly valorized. The higher order construct shapes the ways in which we think about its parts and the questions which we form. Therefore, if we wish to **unthink** educational technology (and I do), we must resist the tendency to break it into parts. This "first unthinking" reveals that not only does educational technology (through ISD models) force upon us a fragmented view of the educational process and of the content or topics of education, but also the field tends to split itself apart for purposes both of research and of self-analysis. If we are to **unthink** educational technology we must struggle to deal with it as a coherent whole.

A holistic view of educational technology

The problem of describing what educational technology is has been addressed by AECT, resulting in a lengthy definition:

> "Educational Technology" is a complex, integrated process involving people, procedures, ideas, devices, and organization for analyzing problems, and devising, implementing, evaluating, and managing solutions to these problems, involved in all aspects of human learning. In educational technology, the solutions to problems take the form of all "Learning Resources" that are designed and/or selected as Messages, People, Materials, Devices, Techniques, and Settings. The processes for analyzing problems and devising, implementing, and evaluating solutions are identified by the "Education-Development Functions" of Research-Theory, Design, Production, Evaluation, Selection, Logistics, and Utilization. The processes of directing or coordinating one or more of these functions are identified by the "Educational Management Functions" of Organization Management and Personnel Management.
>
> *Educational Technology: Definition and Glossary of Terms, 1977*

Implicit in this definition, although it is not explicitly recognized, is the idea of systems:

> . . . systems can be defined as deliberately designed synthetic organisms, comprised of interrelated and interacting components which are employed to function in an integrated fashion to attain some predetermined purpose, Therefore, the best way to identify a system is to reveal its purpose. (Banathy, 1968, pp. 2-3)

Taken together, these definitions confirm the essential character of educational technology as having to do, not with existing holistic phenomena, but rather with a multitude of ideas, agencies, procedures, and artifacts which are brought together and integrated to create "solutions to problems." Although the source and nature of the problems is unspecified, the means of dealing with them and of evaluating their solutions are listed (somewhat cryptically, using terms which are separately defined in the AECT glossary). The problems to be solved through educational technology must, then, be those problems which lend themselves to potential solution and solution assessment through integration of the listed mechanisms into "deliberately designed synthetic organisms." The AECT definition specifies no particular purpose for the systems created; the purpose must be assumed to arise from the context in which educational technology exists, that is, from patriarchy. By its own definition, then Educational Technology is reminiscent of the new hammer in the hands of the young kid who suddenly sees everything as "needing hammering."

While the definition of educational technology specifies little about purpose, it provides a wealth of information about elements to be used in the design and development of applications of the tools and techniques of the technology. Beginning with the statement that Educational Technology is a process, the definition specifies the elements of the process, the forms of the problem solutions, and the assignment of tasks to the constituent parts or practitioners of the field. Analogously to the ways in which science is defined by "the scientific method(s)," educational technology is defined by its process(es). And, analogous to the claim of science to seek an understanding of our universe in all its aspects is the definitional claim of educational technology to deal with problems "involved in all aspects of human learning." Continuing with this analogy, feminist unthinking uncovers ways in which the feminist critique of science can inform a rethinking of educational technology.

Speaking from diverse feminist perspectives, a number of feminists have addressed the questions of whether there can be a feminist science and, if so, how it would be characterized. Among these thinkers/unthinkers, epistemologist Sandra Harding (1986, 1987) has not only critiqued malestream science from several perspectives, but has also identified three essential characteristics of a feminist approach to science: (1) the theorizing of gender as a variable of consequence, (2) the valuing of women's experience as a scientific resource, and (3) the positioning of the researcher in the same critical plane as the researched. Analogues to Harding's observations make visible three areas for feminist rethinking of educational technology. Attention of the field is directed by its definition to "all aspects of ***human*** learning" rather than toward learning by real live people who differ in ways (including gender) which are consequential. Moreover, **people** are among the Learning Resources that can be "designed and/or selected;" the specifically human, specifically gendered, and specifically personal is ignored if not suppressed in educational technology. Secondly, educational technology clearly ignores or rejects the experiences of women as the majority of teachers and as the fifty-or-so percent of learners who have experienced "human learning" in educational settings. (I shall return to these points later.) Thirdly, educational technology is clearly a "top-down" activity; the definition of the field indicates that the Learning Resources, Education- Development Functions, and Educational Management Functions which comprise the process of educational technology exist independently and apart from any specific learner or group of learners. In sum, the feminist epistemological critique of science suggests several important avenues for the unthinking of educational technology.

The ecofeminist critique of malestream science brings feminist unthinking to science and technology, not from the perspective of epistemology, but from that of women concerned about the environment. Carolyn Merchant (1980), one of the "mothers" of ecofeminism frames her historical analysis of science and technology in the set of concerns common to environmentalists and feminists, stating "we must reexamine the formation of a world view and a science that, by reconceptualizing reality as a machine rather than a living organism, sanctioned the domination of both nature and woman (p. xvii)." Not only have ecofeminists continued to be engaged in the unthinking which Merchant began, but they are also engaged in rethinking and transforming science and technology. As Irene Diamond and Lee Quinby (1988) put it, "In place of current scientific theories and practices imbued with questionable notions of certainty, objectivity, and domination, ecofeminist discourse emphasizes indeterminacy, interconnectedness, and nurturance (p. 203)." Ecofeminist considerations invite us to consider whether educational technology perceives the reality of "all aspects of human learning" as more like a free-standing machine than a living social organism, and to unthink this perception. How are educational technology practices of "analyzing problems and devising, implementing, evaluating, and managing solutions" rooted in more general notions of certainty, objectivity, and domination? How do these practices sanction the domination of both nature and women (and men)? Can we rethink educational technology in ways that emphasize indeterminacy and the uncertainty of all "human learning," interconnectedness of (school) learning and lived experience, and nurturance of "the learner" as a real live gendered individual person?

Thus, feminist epistemologies and ecofeminism (together with other feminist theorizing) provide vocabularies, analogies, insights, and energy for the unthinking of educational technology as a process for the design and development of educational interventions, learner deficit models, negative reinforcement strategies, and other "Learning Resources" many of whose very names invite us to continue feminist unthinking of the definition and components of educational technology. Despite the importance of these issues, they do not encompass feminist concerns with regard to educational technology, for these issues all reside within the narrow view of educational technology as an isolated endeavor which might be improved, if not perfected, in and of itself. More important issues arise from the examination of educational technology in other contexts and from other perspectives. In the remainder of this paper I shall turn to one of these contexts, that of the user.

Educational Technology and its Users.

Feminist critiques of technologies have contributed substantially to the technological literature through their examination of the effects of innovations on the practices and the lives of technology users, particularly when those users are women. It is instructive to the unthinking of educational technology to consider an example of this work which has been especially effective in unthinking the media "hype" which promotes household technologies with promises of "less work for mother." Feminist unthinking of the notion that the automatic washing machine is purely and simply a boon to women has uncovered numerous effects on the lives of women in addition to the obvious fact that washing any given load of clothes is a lot easier than it was (Cowan, 1983). As a direct result of the new technology, the activity of washing clothes is no longer a scheduled activity restricted to a particular day, but takes place "as needed." Generally speaking, people have more clothes in need of washing and in need of special attention as they are laundered. Standards for laundering have changed, requiring "colors brighter and whites whiter than white." Clothes washing today is a solitary activity, rather than the peer group or mother-children activity it was in the past. Thus, the automatic washing machine has changed substantialy the daily lives of women, imposing new standards, schedules, and structures on them; at the same time, the "social credit" for laundering has been denied women by the notion that the automatic washer, not the woman who operates it, takes care of the wash.

Educational Technology invites and requires unthinking from the point of view of the user analogous to the unthinking that feminists have applied to household and office technologies. Such unthinking might begin with the examination of both the purported benefits of the technology for the user and the changes which the technology imposes on the users with respect to standards, schedules, social structures, and social credit . As we begin this examination, however, a prior question arises: Who are the primary users of educational technology? Several categories of users are apparent: school systems and their administrators, teachers, children in classrooms, independent students, military trainers, job applicants, trainees in business and industry, and a host of others who are engaged, in one way or another, in seeing to it that some (particular) "human learning" takes place. While recognizing that this diversity of users does affect the nature of the technology, I shall consider only the effects of educational technology on users in schools.

Within the context of schools there are three clearly separated categories of major users of educational technology: school administrators, teachers, and students. Administrators (superintendents, curriculum supervisors, principals) use educational technology as means of implementing local, state, and national educational policies, of standardizing instruction and evaluation, of realizing certain measurable efficiencies, and of meeting parental and community demands that schools be "modern" and "effective." Teachers use educational technology partly as a result of administrative mandates and partly through the selection of instructional media and materials for particular goals and topics of the curriculum. Students are the "end users" of educational technology and use it most often as directed by teachers. Thus, school administrators (primarily male) impose educational technology on teachers (primarily female); in turn, teachers impose educational technology on students of both sexes. Although there is a need to unthink the idea that administrators are "free agents" in this hierarchy of use, I will focus on the teacher and student as users of educational technology.

Teachers as users of educational technology. A feminist unthinking of the effects of educational technology on teachers must begin with the observation that currently and historically the overwhelming majority of U.S. public school teachers of kindergarten through 12th grade are females. Indeed, school teaching has been closely identified with women since Catherine Beecher's 1846 identification of teaching as "woman's true profession;" until the current wave of feminism, the occupational choices available to women were three: secretary, nurse, and teacher. In this statistical and historical context, current criticism of school teachers, whether it come from the Holmes Group's (1986) arguments for reform of teacher education or from Heinich's (1988) arguments for replacing teachers with educational technology, must be viewed at least in part, as suppression of whatever unique qualities and values women currently bring to the activity of teaching. Exactly what qualities these are is not fully known, although nurturance and "the continuation of mothering" are among them (Grumet, 1988; O'Brien, 1989; Laird, 1988). Further feminist study is needed, for amidst the growing literature on feminist pedagogy at the post-secondary level (e.g., Bunch and Pollack, 1983; Culley and Portuges, 1985), there is a curious and serious shortage of feminist studies of teaching of the K-12 grades. Major exceptions are the books of Grumet (1988) and Weiler (1988), both of which highlight the importance of the individual teacher listening to the voices of individual students as she practices the art, not only the science, of teaching.

Like many other technologies, educational technology has been developed largely outside the domain of the user, in this case the teacher, and without the benefit of her wisdom as to how technological advance might help in the pursuit of her art. Instead, the products and processes of educational technology are delivered in fully developed form, sometimes with mandates for their use and sometimes simply as materials which might be useful. Although teachers and teacher magazines complain of it, I am unaware of studies of how this lack of communication effects the classroom usability of these products. However, feminist studies of comparable practices in relation to office computerization clearly indicate that, had the women workers been consulted during the design of the specific systems they are required to use, the result would have been systems which were more appropriate both for the immediate user and for achieving the goals of the implementation (Suchman and Jordan, 1988; Zuboff, 1988). An unthinker needs to ask why teachers are not major actors in the specification, design, and development of educational technology. Is their exclusion simply an example of what Mary O'Brien (1989) sees as the continued exploitation of teachers by the establishment *because* they are women? Is it an extension of Barbara Garson's (1988) observation that "The underlying premise of modern automation is a profound distrust of thinking human beings" (p.261)? Or is it that the goals of educational technology are so discrete from the goals of teachers that the experiences of teachers are irrelevant to the design of educational technology?

If the design process of educational technology denies the value of the experiences of the teacher as an information resource, the implementation processes effect the structures, standards, and schedules by which she plans and performs her work. Computer managed instruction and competency based testing elevate the importance of some types of learning while limiting the teachers' choices and involvement within the instructional process; thus, they deny the value of any wisdom or insight she may have gained from her years of teaching. The possibilities for flexible planning of activities which are finished only when students reach some sort of closure on the topic are diminished by the need to use computer labs, broadcast television, or scarce hardware on an often fragmented schedule not of her making; chaos and the feeling that nothing is ever completed is introduced into the teachers' life. The inability to preview materials as students will experience them, either because of their prior unavailability or because complex branching precludes any examiniation of the full range of possibilities, renders the teacher less knowledgable with respect to students' actual experiences and at a loss for helping students who experience difficulty making connections or who encounter any sort of software failure.

In short, the structures, standards, and schedule of the teacher's school day become out of her control. The delivery of information, and the modelling of the use of this information, are increasingly removed from her; often the information provided to her students is not even readily available to her. Research on the effectiveness of educational technology denies the importance of her work, "meta-analyzing" her contributions out of the picture. As many writers on the future of schooling have observed, the teacher is increasingly a manager and facilitator. Her position becomes very much like that of the woman-as-laundress of our example. As schedules of instruction become more complex, as the standards for student acquisition of "competencies" increase in number, and as expert systems, ICAI, interactive video, and other new technologies decrease the teacher's familiarity with the topics of instruction, apparently she will still be charged with the management of "human learning activities;" that is, she will be responsible for seeing that "human learning" takes place. Will she receive social credit for teaching when students learn? Or, will "educational technology" take care of that?

Students as users of educational technology. In thinking/unthinking about students as users of educational technology, I shall focus my attention on female students. However, a few general comments are important. The language of educational technology tends to deny the essence of the real live person who is the "end-user" of the technology. No longer a **student** (who studies), this person is positioned within educational technology as "the learner." (Taylor, 1987). The generic learner does not behave but exhibits behaviors, is not able but has capabilities, does not look at things but is presented with stimulus material, does not perform but meets criteria, and so on; in short, "the learner" is positioned as non-autonomous and passive by the language, attitude and rigors of educational technology. Similar positions are held by army recruits enduring the rigors of boot camp and by fraternity pledges undergoing hazing; it is a male position. Sally Hacker (1989), in her feminist examination of the commonalities of military training and engineering education, theorizes the importance of such positioning to the continuance and reproduction of patriarchy. Further unthinking which extends Hacker's work to an examination of school education and of educational technology is needed; however, in the meantime, we should not lose sight of the influence of the field of military training on the forms and functions of educational technology.

Beyond this positioning, educational technology reproduces patriarchy because it inherits and reproduces all the gender biases of its root fields and of the fields of "human learning" to which it is applied. Biases inherent in learning psychology, in the various technologies of media and materials, in educational measurement, and in the gendered subjects of school instruction interact multiplicatively as they are brought together in educational products for student users. A brief recap of some of these biases and their effects can inform our unthinking. Uncovering the ways in which the bodies of content of subject matter instruction are gendered has been the major project of the field of Women's Studies. Although the gender biases inherent in the canons of literature and the study of history have been examined most fully, the work of Sandra Harding (cited above) and of many other feminists who study science and/or philosophy has uncovered serious bias in the sciences; no field of study is immune to the presence of clearly gendered content, if not in the major concepts and underlying principles of the field, then in its illustrative examples, its canonized exemplars, or its applications.

The effects of gendered content upon female students can be numerous: the undervaluing of female potential, cognitive dissonance, and the confounding of cognitive and affective learning. Consider, for example, the plight of the pubertal young woman learning in biology class that females are "unfinished males."

The gendering of psychology merits special consideration because educational technology derives principles from psychological learning theory and implements practices based upon psychological measurement. The gendering of psychology is especially pernicious because one stated intent of the field is to study and understand sex differences. As early as 1903 (when psychology was still a very young field), the female psychologist Helen Thompson Woolley argued that the discipline was plagued with sex bias, especially in the area of sex differences research. Since that time, numerous scientists have expanded on Woolley's observations. Recent feminist writings on the topic include Corinne Squires' (1989) analysis which reveals that feminist psychologists have found psychology to be non- egalitarian at all levels. Not only are the researchers primarily male, and the subjects (who are the objects) of study historically male, but also the methods and theories are biased in gender specific ways. For example, the standard methods of psychological investigation vary with the (prior or presumed) gender correlates of a trait under study; characteristics which are considered to be male are studied using high status, active experimental methods, while those considered to be female are studied using lower status, passive methods such as questionnaires and observation. Thus at the level of investigation, methods and gender are confounded. Margrit Eichler (1988) has identified four primary problems of sexism which characterize psychological (and educational) research: androcentricity, overgeneralization, gender insensitivity, and double standards. As shown in her analysis, these problems manifest themselves in all stages of the research process, beginning with the choice of value laden topics for study and culminating in the sexist choice of interpretations and languages used in the reporting of results. Eichler observes that the use of the null hypothesis, and the labelling of results as "significant" only when the hypothesis is rejected, creates a literature of difference. As a consequence of this research practice, all "significant" results in the psychological study of gender must point away from samenesses of the sexes. As Allison Jaggar (1987) and other feminists have argued, the overall effect of sex differences research (and the publicity surrounding it) is to rationalize and reproduce inequality.

Procedures and practices of Educational Technology tend to play a considerable role in the reproduction of inequality. The educational research on which educational technology relies is saturated with studies of sex differences, so much so that when studies reveal no sex differences the researcher is almost obliged to follow up with some sort of ATI study which will uncover a variable whose interaction with sex can "clarify" and "deepen" our understanding of how gender operates in relation to the original question. Such studies form the starting point for most research on instruction and the development of instructional procedures, and are also used in relation to research related to cognitive psychology and expert systems. After a difference in the measured performance of two groups is identified, representatives of the groups are studied in more detail with the object of determining characteristics which are present among the high performers and absent among the low performers. These characteristics are valorized through their naming and their designation as new instructional objectives. Instruction is then designed to help the low achievers reach these new objectives. The process is recursive in that it can be repeated with new objectives, thus dividing the instruction into smaller and smaller bites. Whenever the high achievers are predominantly male (as they are in math and science, especially) one effect of the process is to program females to behave like males. Another noteworthy effect of the procedure is that, because instruction is modelled on the spontaneous behavior of the achieving male, he is in no danger of losing his status as an achiever; if anything, his status is increased with the number of objectives that he can meet effortlessly. The implications for the female are entirely different; already caught in the recursive refinement of male objectives, her responses to a "learning situation" go unnoticed; they are neither categorized and named, nor reified as objectives. Whatever her reasons for so responding, and whatever the process of responding may have contributed to her personal learning (building her cognitive structure, if you will) remain hers alone, to be supplemented with the new "more appropriate" learning.

In summary, educational technology as used by students is thoroughly saturated with the biases of its root disciplines and curricular contexts. Gendered subject matter has different meanings for females than for males, and, therefore, is likely to elicit different responses and different strategies for dealing with it. When these differences result in measured differences in performance with respect to standards which are derived from the male definition of appropriate learning, the process of educational technology intervenes with products designed to instruct females on the details of male behavior in response to the topic. Initial interpretations and learning by females go unrecognized in the educational technology system (although they remain with the female). These gender biases and effects permeate all of education; however, by eliminating "noise" such as indeterminacy, ambiguity, and inefficiency from the instructional process, educational technology has the potential to perpetuate these biases in their purest form.

In diferent ways the contributions of the teacher user and the female student user to the teaching-learning process are denied by the increasing use of educational technology. For the teacher this denial takes the form of simultaneously decreasing her authority with regard to the content of instruction, increasing the level of ambiguity in her day-to-day activity, and depriving her of social credit for the increasingly complex job which she performs. For the female student, denial is more subtle. Although the learning resources that she uses may be free of overt sexism, the deeply gendered characteristics of the learning environment and of her daily experience work together to deny her cognitive autonomy.

This unthinking of the effects of educational technology on its student and teacher users is but one beginning; a different unthinking or a further unthinking might bring to bear feminist research on women's ways of knowing (Belenkey et al, 1986) which posits a new and female-grounded stage theory of learning; it might spring from a feminist analysis of the the politics of education, or from a feminist deconstruction of educational equity. Additional contextual studies of educational technology should examine effects on other users, as well as the positioning and meaning of educational technology in social, cultural, historical, environmental, and other contexts. Analyses similar to the user analysis of this study should consider users from different races and classes within our society. In short, the paragraphs above comprise but one of the many ways in which it is both possible and essential for feminists to unthink educational technology.

ReThinking, Energizing, Transforming

Feminist unthinking, like post-modern deconstruction, shatters myths of value neutrality and frees us from the tyrrany of absolutism; it allows the rethinking and reconstruction of texts and technologies from new value bases. Feminist unthinking is not a form of Luddism, but begins with the premise that technologies are neither wholly good nor wholly bad. Technologies are products of the societies from which they emerge, and our society is patriarchal; it is no surprise, therefore, that feminist unthinking begins to unravel ways in which educational technology is deeply gendered and massively sexist. The question for feminist educators is whether unthinking its myths reveals educational technology to be so heavily valenced toward the masculine that it can have no place in a feminist society; or, on the other hand, does the unthinking suggest ways in which it can be rethought as a more feminist technology.

The unthinking of the previous pages evokes several questions which might guide feminist rethinking of educational technology, among them the following: Can the monolithic hierarchical structure of "educational technology" be rethought as a group of diverse "technologies of education"? What technologies of education would teachers invent? And how would they use them? How can we re-invent a technology of education based upon some of the new feminist research on the psychology of women? How can the power and flexibility of the computer be used to make the experiences, writings, and products of women (as well as men) available to students as valuable learning resources? How can multiple technologies be used in the education of students with multiple interpretations of texts, experiences, and reality? How can educational technology foster students' understanding of the interrelatedness of perceptions and phenomena, and of indeterminacy? What is the place of technology in a nurturing educational environment? How can technologies be used in ways that do not deny the realities and needs of the individuals using them? To take these questions seriously is to find energy and to begin to transform educational technology.

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Title:

Effects of Students' Prior Knowledge and Presentation Mode on Achievement (Visual/Verbal Testing) of Different Educational Objectives

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Effects of Students' Prior Knowledge and Presentation Mode on Achievement (Visual/Verbal Testing) of Different Educational Objectives

Abstract

The purposes of this study were to determine (a) the effectiveness with which different types of rehearsal strategies complementing visualized instruction facilitates student achievement, (b) the effect of different instructional treatment on students' processing different prior knowledge levels and (c) whether verbal and visual tests are equally effective in retrieving information acquired from visualized instruction. One hundred twenty students enrolled at The Pennsylvania State University were randomly assigned to four treatment groups which determined both the method of instruction and testing mode they received. Students received their respective instructional presentations and criterion tests in one session. Analyses indicated that: (a) students possessing different entry levels of prior knowledge profit differentially from the different treatments; (b) differences in achievement potential among students with prior knowledge levels can be reduced in terms of information acquisition by providing treatments with elaborate rehearsal activity; (c) identical treatments are not equally effective in promoting student achievement for different types of educational objectives and (d) visual testing is a viable strategy for retrieving information acquired by students receiving visualized instruction.

Introduction

Rehearsal

Considerable research (Paivo, 1971, Tulving, 1976, Dwyer, 1978, 1987) has indicated that visualized instruction alone does not always maximize student learning. Gagne (1977) indicated that learning is a highly idiosyncratic event, and depends very much on the nature of the learner - particularly on his prior learning. In order for learning to be effective at any level, the learners must be active (Bork, 1979; Bransford, 1979; Travers, 1970). In this regard, Murray and Mosberg (1982) have indicated that the longer an individual can be in rehearsal type activities with the content material, the greater the probability that learning will occur and be retained. Mental activity on the part of learners is essential for learning to occur. This activity includes the selection and perception of stimuli; encoding of new stimuli, and the retrieval of prior knowledge for use in combination with the new stimuli for imaging, comparison, analysis, synthesis, and problem-solving. Varied forms of rehearsal, while focusing attention, allow time for incoming information to remain in short-term memory long enough to be elaborated upon and encoded for long-term memory (Anderson, 1980; Dushkin, 1970; Lindsay & Norman, 1972; Murray & Mosberg, 1982). Lindsay and Norman (1972) have argued that the longer an item is maintained in short-term memory by rehearsal, the greater the probability that it will be transmitted into long-term memory and be retained.

In general, rehearsal can be considered to be any mathemagenic activity that can serve the learner in several ways including motivating and promoting appropriate mental activity. Additionally, different rehearsal strategies differ in intensity of learner involvement and, thus, may have differential effects on specific learning outcomes. It may be that the effectiveness inherent in rehearsal is that it allows the learner to process information simultaneously on several levels. If this is the case, then it may also follow that optimum intensity of rehearsal activity (actual overt interaction with the content material) may be directly related to the level of learning to be achieved--the more complex learning requiring the most intense or involved type of rehearsal activity. For example, covert rehearsal generally requires minimal information processing activity on the part of the learner. Examples of covert rehearsal include reading prose passages, reading summary statements, reading questions and answering them mentally before checking with a given answer, and following mentally the completed solution of a problem. Researchers have found that reading correct statements or correct answers does not always provide for a level of mental processing that results in increased understanding (Anderson, Goldberg, & Hiddle, 1971; Bransford, 1979). Overt rehearsal, by providing physical activity in which the learner is required to interact with the content material, ensures that he/she attends to the information and spends more time interacting with and encoding the information.

Visual Testing

The transmittal and retrieval of information are primary concerns in any instructional/training environment. In considering factors that might enhance information acquisition and retrieval, Tulving and Thomson (1973) have proposed the encoding specificity principle--that recognition memory is better if the cues used in the original instructional/acquisition environment are used in the testing retrieval environment. Similarly, Battig (1979) and Nitsch (1977), in adhering to the encoding specificity principle, have indicated that any change in the retrieval environment from that which occurred in the original learning environment produces marked decrements in learner performance.

Support for the use of visual test items that employ visuals of the same type as those employed in the instructional has surfaced regularly in the research literature in the form of hypotheses and theories; for example, the sign-similarity hypotheses (Carpenter, 1953), cue summation theory (Severin, 1967), stimulus-generation theory (Hartman, 1961), encoding specificity principle (Tulving and Thomson, 1973), and transfer-appropriate processing principle (Morris, Bransford, and Franks, 1977). In this regard Lindsay and Norman (1977, p. 337) have stated that in the teaching-learning environment, "the problem in learning new information is not getting the information into memory; it is making sure that it will be found later when it is needed." Bransford (1979), Tulving (1979), and Tulving and Osler (1968) have indicated that the accuracy with which information is retrieved is related to the degree of elaborateness of the encoding which occurred during the rehearsal activity. Similarly, Tulving and Thompson (1973), in discussing the retrieval of encoded information, maintain that memory is better if the cues used in the original information activity are employed in the retrieval situation.

Consequently, information retention level is assumed to be a direct function of the encoding occurring at the presentation stage and the degree to which the retrieval environment recapitulates this encoding (Battig, 1979; Tulving, 1979). The implications of this position would imply that in instructional situations where visualization was utilized in the encoding process and was not used in the retrieval (decoding) process, learner performance measures would yield gross underestimates, if not distortions, with respect to what and how much information had been originally acquired. This conceptualization suggests that information retrieval is a very specific process, easily disrupted. Since the features of the original learning cues are processed during a test, any reduction in the individual distinctiveness of the cues themselves should produce concomitant reductions in recall (Nelson, 1979).

Problem Statement

The purpose of this study was to investigate the instructional effectiveness of integrating rehearsal activity into visually complemented prose instruction. Within this context the instructional effectiveness of both overt and covert rehearsal activity was examined. Additionally, the study examined the students' level of prior knowledge on learning and the effect of visual/verbal testing. Specifically, the purpose of this study was to determine whether (a) students possessing different prior knowledge levels profit differentially from different instructional treatments, and (b) visual testing is a viable strategy for retrieving information acquired by students receiving visualized instruction.

Verbal and Visual Tests (Criterion Measures)

Students in each instructional group participated in their respective treatments followed immediately by a drawing test. Each student then took three separate 20-item multiple-choice criterion tests, either in the verbal format or visual format. Scores in these three individual criterion tests (identification, terminology, and comprehension) were combined into a 60-item composite test score.

The three multiple-choice tests (verbal format) used in this investigation were developed by Dwyer (1972). Additional revisions were made to selected multiple-choice questions to further eliminate the ambiguity of specific distractors and to attempt to prevent a specific question and its distractors from clueing another answer (Dwyer, 1985-1986). The format of each of the 60 multiple-choice items consisted of a typical verbal stem and verbal response options. The following description of the criterion tests, adapted from Dwyer (1978, pp. 45-47) illustrates the kinds of educational objectives assessed in this study.

Drawing Test The objective of the drawing test was to evaluate student ability to construct and/or reproduce items in their appropriate context. The drawing test (20 items) provided the students with a numbered list of terms corresponding to the parts of the heart discussed in the instructional presentation. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents.

Identification Test (Verbal and Visual Format) The objective of the identification test was to evaluate student ability to identify parts or positions of an object. This multiple-choice test (20 items) required students to identify the numbered parts on a detailed drawing of a heart. Each part of the heart, which had been discussed in the presentation was numbered on a drawing. The objective of this test was to measure the ability of the student to use visual cues to discriminate one structure of the heart from another and to associate specific parts of the heart with their proper names.

Terminology Test This test consisted of 20 multiple-choice items designed to measure knowledge of specific facts, terms, and definitions. The objectives measured by this type of test are appropriate to all content areas that have an understanding of the basic elements as a prerequisite to the learning of concepts, rules, and principles.

Comprehension Test The comprehension test consisted of 20 multiple-choice items. Given the location of certain parts of the heart at a particular moment of its functioning, the student was asked to determine the position of other specific parts of the heart at the same time. This test required that the students have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The comprehension test was designed to measure a type of understanding in which the individual can use the information being received to explain some other phenomenon.

Composite Test Score The items contained in three of the four individual criterion tests (identification, terminology, and comprehension) were combined into a 60-item composite test score. The purpose was to measure the total achievement of the varied levels of objectives presented in the instructional unit.

In designing the visual test formats for each criterion test, the visual tests developed by De Melo (1980) were used as a guide. De Melo's visual tests utilized four or five drawings as distractors for each question. The revised version of the visual form of the criterion tests utilized only one drawing with four or five letter labels in all items in which it was possible to do so while maintaining clarity and correspondence to the verbal test items (see Figure 1). However, two items in the terminology test and all items in the comprehension test required four drawings. The item stems of both the verbal and visual test questions were verbal and asked the same question. In addition, the visual distractors in the visual tests corresponded to the verbal distractors in the verbal tests as closely as was reasonable. The description of the verbal tests given previously also describes the visual tests.

Figure 1 About Here

Instructional Treatments

Each of the four instructional treatments in this study contained the same instructional script, visuals, terminology labels, and arrows. The treatments differed only in the degree of rehearsal employed (covert or overt) and the type of testing employed (verbal or visual). Figure 2 (Plate 1) illustrates a sample frame received by students in Treatments 1 (Reading Summaries - Verbal Test) and Treatment 2 (Reading Summaries - Visual Test). Students in both treatments received the same instruction; however, students in Treatment 1 received verbal tests while students in Treatment 2 received visual tests. The summary statements at the end of each page required a minimal amount of covert rehearsal on the part of the students and did not review all the information in the instructional script. The summary statements were designed to provide the students with the opportunity for mental review of the instructional content.

Students in Treatments 3 (Overt Visual Rehearsal-Verbal Test) and Treatment 4 (Overt Visual Rehearsal-Visual Test) received identical instruction (Figure 2, Plate 2); however, students in Treatment 3 received verbal tests while students in Treatment 4 received visual tests. These treatments required that students shade with colored pencils the specified parts and functions of the heart. The parts and functions to be shaded corresponded to, as closely as possible, the information summarized in Treatments 1 and 2. The colors used were selected to avoid a sense of color coding: black, green, yellow and red. Red was used in two circumstances in which four colors were required on a page; association of the red color with oxygen-rich blood was avoided.

Instruction was presented to students in booklet format and students were permitted to spend as much time as they needed to interact with the instructional content and to complete the criterion tests.

Figure 2 About Here

Design and Analyses

One hundred twenty undergraduate students enrolled at The Pennsylvania State University participated in this study. A pretest consisting of 36 items on general content in physiology (Dwyer, 1972) was utilized in this study. The pretest was used to determine students' prior knowledge level regarding human physiology. Scores on the pretest were arranged in decending order from highest to lowest. The top 40 scores represented high prior knowledge (M=27.3), the next 40 medium prior knowledge (M=21.8) and the bottom 40 low prior knowledge (M=17.1). The Formula 21 reliability of the physiology pretest was .84 and its correlation with the total composite tests was .56. Students in each of the three prior knowledge levels were then randomly assigned into one of the prior treatment groups. The independent variables manipulated were levels of prior knowledge, level of rehearsal strategy (covert/overt) and test mode (verbal/visual). The dependent variables were (a) performance on the visual and verbal versions of the individual criterion tests--terminology, identification, and comprehension, (b) performance on the composite test, and (c) performance on the drawing test.

Alpha was set at the .05 level for each analysis of variance. Where significance was found to exist Tuhey's Wholly Significant Difference (WSD) for comparison among the means was utilized.

Results

Table 1 presents the means, variances and reliability coefficients on the criterion tests. Analyses of variance indicated that significance differences existed on the drawing (F=9.62, d_f=3/108, p. <.05), identification (F=19.86, d_f=3/108, p. <.05), terminology (F=22.63, d_f=3/108, p. <.05), comprehension (F=34.15, d_f=3/108, p. < .05) and composite tests (F=31.06, d_f=3.108, p. <.05). Figure 3 illustrates the comparison of mean achievement scores for each prior knowledge level on each of the criterion measures. These comparisons generally indicate that Treatment 4, the shading on pictures (overt rehearsal): visual testing, was the most effective in facilitating information acquisition. Table 2 shows where significant differences occurred in achievement among students possessing different prior knowledge levels (High, Medium, Low) as the five criterion measures. The blank areas indicate where significant differences in achievement did not occur. These results illustrate the fact that the low prior knowledge group is the group which is most positively influenced by the different instructional strategies. Additionally, Treatment 4 was the instructional format which was most instrumental in reducing the effect of differences among students in the prior knowledge levels.

Table 1 About Here

Figure 3 About Here

Table 2 About Here

Table 3 illustrates the results of comparing student performance receiving similar instruction but receiving tests in the different evalution modes. Insignificant differences were found to exist between students who received the reading summaries treatment which were evaluated by both visual and verbal tests. However, in evaluating the differences between Treatments 3 and 4, Treatment 4 the Shading on Drawing (Overt Rehearsal) Visual Test was found to be significantly more effective than Treatment 3 on all the criterion measures.

Table 3 About Here

Discussion

Considerable research on the design and use of visuals has shown that visualization can significantly improve students' learning from prose instruction (De Melo, 1980; Dwyer, 1978; Dwyer & Parkhurst, 1982; Levie & Levie, 1975, 1971). The review of literature for this study indicated that rehearsal strategies and the visual test mode are important instructionalvariables. The present study went one step beyond merely establishing the importance of visualization but attempted to determine (a) the effect of different rehearsal strategies used to complete visualized prose instruction, (b) the effect visual testing in retrieving information and (c) the effect that different instructional strategies have on students possessing different prior knowledge levels.

Results of this study indicate that all types of rehearsal strategies are not equally effective in facilitating student achievement of different educational objectives (Figure 3). The general trend also seems to indicate that overt rehearsal is more effective than covert rehearsal in facilitating student achievement. Additionally, it was found that within the overt rehearsal treatments when significant differences were found to exist students who received the visual test mode achieved significantly higher scores than did students who received the verbal tests. The higher scores on the visual tests by students in Treatment 4 may be explained by the encoding specificity principle (Battig, 1979; Nitsch, 1977; Tulving, 1979) since the visual test situation in this study closely matched the learning situation; the visuals employed in the test situation provided the critical cues needed by students to retrieve the encoded information (Bransford, 1979). These results are also congruent with the sign-similarity hypothesis (Carpenter, 1953), the stimulus-generalization hypothesis (Hartman, 1961), the cue summation theory (Severin, 1967), and the transfer-appropriate principle (Morris, Bransford, & Franks, 1977).

In comparing the results of the verbal-visual mode of testing on the different criterion measures (Table 3) insignificant differences were found to exist between students in Treatments 1 and 2. Two possible explanations may be proposed for this finding: (a) the reading summaries treatments (covert rehearsal) apparently did not provide enough maintenance rehearsal to allow for additional elaborative rehearsal that would encode more information from short-term memory into long-term memory, and (b) performance on the visual test may have been influenced by the fact that visual tests are rather unfamiliar to most students and their performance on them suffered accordingly.

In examining the effect of the verbal-visual testing mode (Treatment 1 vs. Treatment 2 and Treatment 3 vs. Treatment 4: Table 3) insignificant differences were found to exist between Treatments 1 and 2 on all criterion measures; however, Treatment 4, the visual test format was found to be significantly more effective than its counterpart the verbal testing format on all criterion measures. Apparently, the visual rehearsal which required that students overtly interact with the instructional content by requiring them to color and draw on the visuals functioned to provide appropriate conditions for encoding; thus, it was possible for students to retrieve more information on the visual criterion tests. This finding seems to support the encoding specificity principle (Tulving and Thomas, 1973) which contends that recognition memory is better if the cues used in the original instructional/acquisition environment are used in the testing/retrieval environment. Additional related research tends to support this position (Nitsch, 1977; Battig, 1979; Morris, Bransford & Franks, 1977; Dwyer & De Melo, 1984; Dwyer & Dwyer, 1985).

In examining the effect of the different treatments on students possessing different levels of prior knowledge (Table 2), the results indicated that Treatments 1 and 2 had moderate effects in reducing prior knowledge differences on the criterion tests and when they did occur differences between the medium and low prior knowledge levels were effected. Treatment 3 was effective in reducing all differences between the low and medium prior knowledge levels. On three criterion measures differences between the low and medium prior knowledge levels were reduced. Treatment 4, shading on pictures, visual test, influenced student performance in all the criterion tests dramatically by reducing performance differences attributed to levels of prior knowledge. The success of this treatment may be an indication of the dual coding which occurred (Paivio, 1971)--verbal encoding from the interaction with the verbal text and visual encoding from the repeated interaction with the visualized content. This repeated interaction resulted in a greater amount of information being encoded relative to the functions of the heart and the relationships between the parts of the heart. It may be that students by their sustained and repeated interaction with the visuals in Treatment 4 maintained more information in short-term memory for longer periods of time which allowed for more elaboration (by students of all levels) and storage in long-term memory (Craik & Watkins, 1973). This is consistent with Travers' (1982) statement that short-term memory is where information is organized and prepared for long-term memory. The achievement of higher scores did require a higher level of processing, more elaborations, more "links," more reflection, etc. In this regard, the data indicated that more information was encoded in the visual rehearsal situation as tested by the visual criterion tests.

Summary

The results of this study reveal that all types of rehearsal strategies used to complement visualized instruction are not equally effective in facilitating student achievement of different educational objectives and that visual testing is an important instructional variable for facilitating the retrieval of optimum amounts of acquired information. The finding that is is possible to develop an instructional-evaluation strategy (i.e. Treatment 4) which can reduce differences attributed to prior knowledge levels is significant for future instructional design and development activities. However, it is important that these findings be reflected with larger and more varied audiences before these findings are generalized too broadly.

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Plate 1—Sample questions from the identification test (visual format).

aortic valve

left auricle

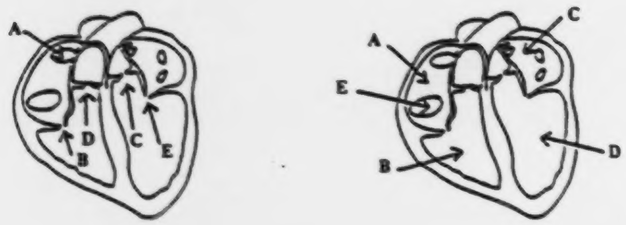


Plate 2—Sample questions from the terminology test (visual format).

The chamber of the heart that pumps oxygenated blood to all parts of the body:

The part(s) of the heart that control(s) its contraction and relaxation:

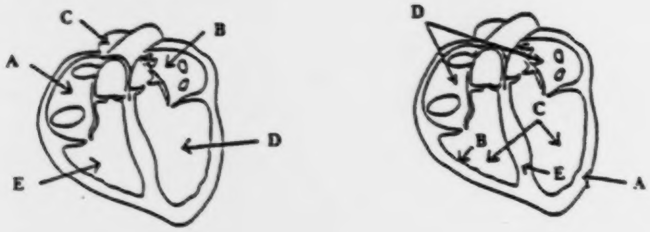


Plate 3. Sample questions from the comprehension test (visual format).

The parts of the heart though which blood is being forced during the second contraction of the systolic phase:

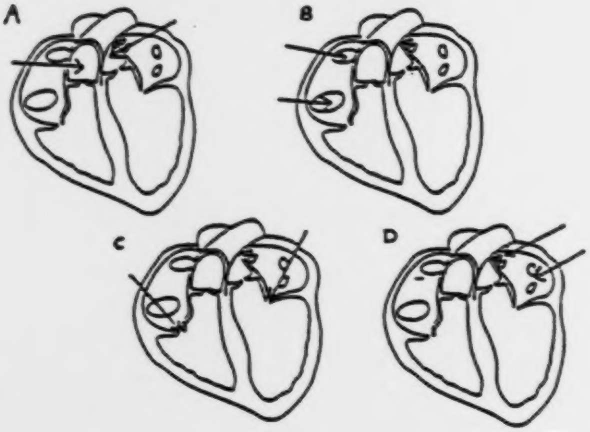
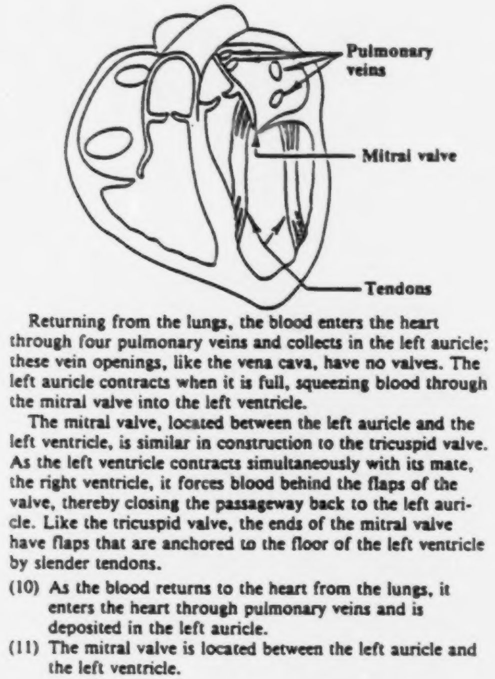


Figure 1—Sample questions from the tests in the visual format.

Figure 2. Samples of the Rehearsal Strategies

Plate 1. Sample page from Treatment 1 (Reading Summaries: covert rehearsal)

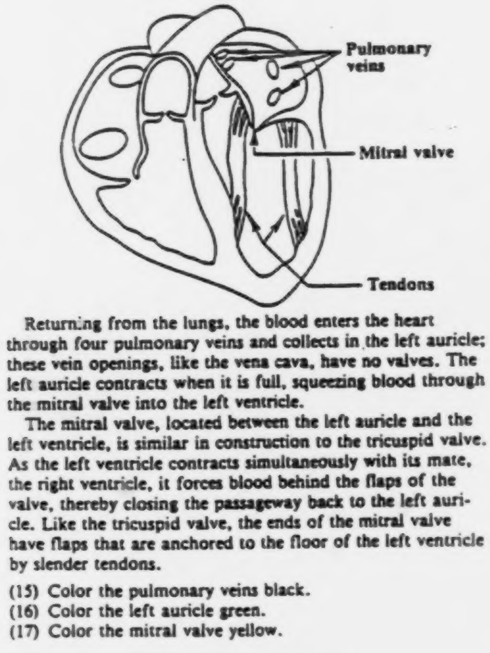

Pulmonary veins
Mitral valve
Tendons

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cava, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps that are anchored to the floor of the left ventricle by slender tendons.

(10) As the blood returns to the heart from the lungs, it enters the heart through pulmonary veins and is deposited in the left auricle.
(11) The mitral valve is located between the left auricle and the left ventricle.

Plate 2. Sample page from Treatment 3 (Shading on Drawing: overt rehearsal)


Pulmonary veins
Mitral valve
Tendons

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cava, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps that are anchored to the floor of the left ventricle by slender tendons.

(15) Color the pulmonary veins black.
(16) Color the left auricle green.
(17) Color the mitral valve yellow.

Figure 3. Comparison of Mean Achievement on the Criterion Tests

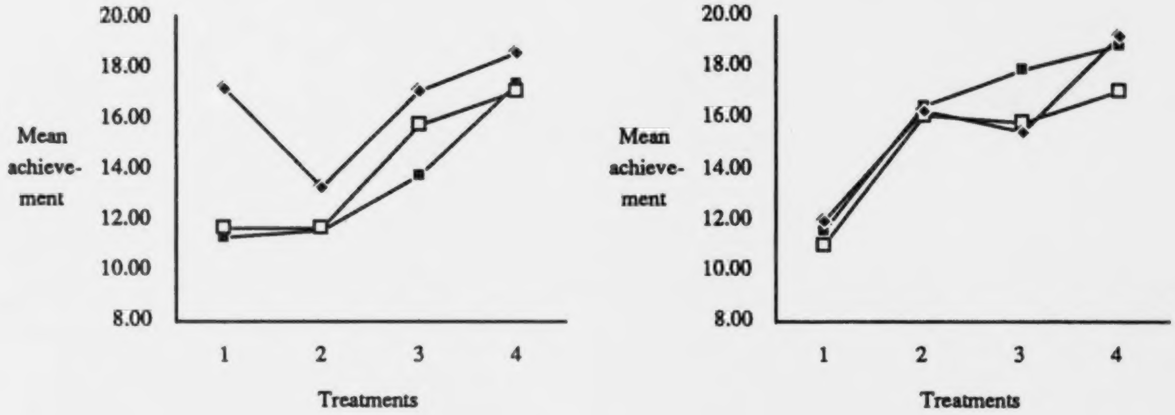


Plate 1. Terminology Test

Plate 2. Drawing Test

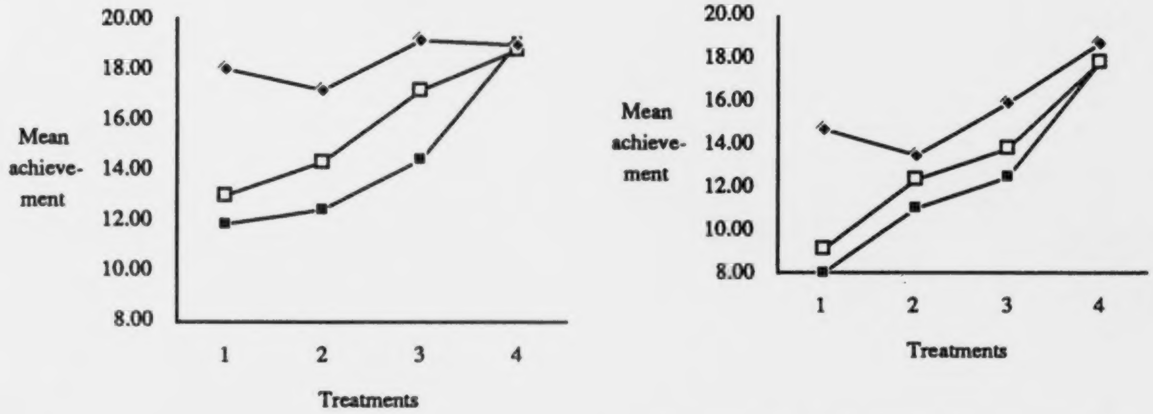


Plate 3. Identification Test

Plate 4. Comprehension Test

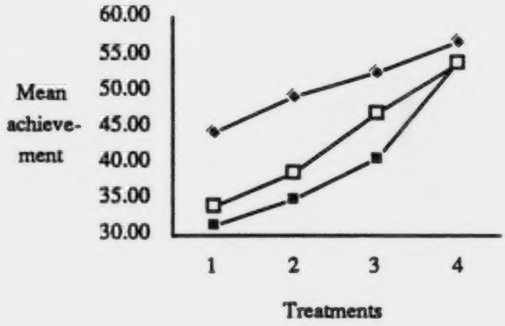


Plate 5. Composite Test

Legend

-◆- High prior knowledge level

-□- Medium prior knowledge level

-■- Low prior knowledge level

Treatments
1. Reading summaries (covert rehearsal): verbal tests
2. Reading summaries (covert rehearsal: visual tests
3. Shading on pictures (overt rehearsal): verbal tests
4. Shading on pictures (overt rehearsal): visual tests

Table 1. Means, Variance Estimates and Reliability Coefficients on the Criteria Tests

TREATMENTS		Criterion Tests				
	Items	Drawing (20)	Terminology (20)	Identification (20)	Comprehension (20)	Composite (60)
Treatment 1. Reading Summons (Covert Rehearsal: Verbal Test	Mean	13.97	13.40	14.30	10.60	38.30
	Variance	11.60	7.82	7.18	9.36	56.18
	K-R 21	.79	.71	.81	.74	.87
Treatment 2. Reading Summons (Covert Rehearsal: Visual Test	Mean	14.47	12.20	14.63	12.30	39.13
	Variance	11.60	7.82	7.18	9.36	56.18
	K-R 21	.81	.63	.77	.67	.72
Treatment 3. Shading on Pictures (Overt Rehearsal): Verbal Test	Mean	15.93	15.57	16.93	14.13	46.60
	Variance	11.60	7.82	7.18	9.36	56.18
	K-R 21	.77	.83	.73	.79	.83
Treatment 4. Shading on Pictures (Overt Rehearsal): Visual Test	Mean	18.27	17.70	18.97	18.20	54.80
	Variance	11.60	7.82	7.18	9.36	56.18
	K-R 21	.83	.80	.79	.69	.78

Table 2: Effect of Instructional Treatment on Prior Knowledge Level on Each Criterion Test

	Instructional Treatments			
Criterion Tests	Treatment 1: Reading Summaries (Covert Rehearsal): Verbal Test	Treatment 2: Reading Summaries (Covert Rehearsal: Visual Test	Treatment 3: Shading on Pictures (Overt Rehearsal): Verbal Test	Treatment 4: Shading on Pictures (Overt Rehearsal): Visual Test
Pretest	1>2 1>3 2>3	1>2 1>3 2>3	1>2 1>3 2>3	1>2 1>3 2>3
Drawing Test	1>2 1>3	1>2 1>3	1>2 1>3	
Identification Test	1>2 1>3 2>3	1>2 1>3 2>3	1>2	
Terminology Test	1>2 1>3	1>2 1>3	1>2	
Comprehension Test	1>2 1>3 2>3	1>2 1>3	1>2 1>3	1>2
Composite Test	1>2 1>3	1>2 1>3 2>3	1>2	

1 = High prior knowledge level
2 = Medium prior knowledge level
3 = Low prior knowledge level

Table 3: Comparison of Visual-Verbal Testing on the Criterion Measures

	Drawing Test	Terminology Test	Identification Test	Comprehension Test	Composite Test
TREATMENTS	1=2	1=2	1=2	1=2	1=2
	4>3	4>3	4>3	4>3	4>3

.05 Level

Treatment 1. Reading Summaries (Covert Rehearsal): Verbal Test
Treatment 2. Reading Summaries (Covert Rehearsal): Visual Test
Treatment 3. Shading on Drawings (Overt Rehearsal): Verbal Test
Treatment 4: Shading on Drawings (Overt Rehearsal): Visual Test

Table 2: Effect of Instructional Treatment on Prior Knowledge Level on Each Criterion Test

	Instructional Treatments			
Criterion Tests	Treatment 1: Reading Summaries (Covert Rehearsal): Verbal Test	Treatment 2: Reading Summaries (Covert Rehearsal: Visual Test	Treatment 3: Shading on Pictures (Overt Rehearsal): Verbal Test	Treatment 4: Shading on Pictures (Overt Rehearsal): Visual Test
Pretest	1>2 1>2 2>3	1>2 1>3 2>3	1>2 1>3 2>3	1>2 1>3 2>3
Drawing Test	1>2 1>3	1>2 1>3	1>2 1>3	
Identification Test	1>2 1>3 2>3	1>2 1>3 1>3	1>2	
Terminology Test	1>2 1>3	1>2 1>3	1>2	
Comprehension Test	1>2 1>3 2>3	1>2 1>3	1>2 1>3	1>2
Composite Test	1>2 1>3	1>2 1>3 2>3	1>2	

1 = High prior knowledge level
2 = Medium prior knowledge level
3 = Low prior knowledge level

Title:

Diagnostic Evaluation of Composition Skills: Student Choice

Author:

Herbert J. Dwyer

ABSTRACT

This study investigated student preferences for either teacher-written or computer-generated marking of written compositions. Ninety-seven high school students typed assigned compositions on a word processor. Three skills pre-selected by the teacher were checked on each composition. Students were randomly assigned to treatments so that, on the first composition, one-half were marked by the teacher and the other half by a computer proofing program. On the second assignment, the teacher/computer groups were switched to the opposite type of marking. On a third assignment, students chose either teacher or computer marking. Results showed that, after experiencing both types of marking, 87% of the students selected teacher marking over computer marking. The most common reasons for selecting the teacher were the more personalized marking, ease of understanding, additional areas marked, and the fact that the teacher is the ultimate grader. Students reported that they liked using word processors (86%) and that word processors made writing easier (93%).

Diagnostic Evaluation of Composition Skills: Student Choice

The introduction of computers into language arts classes has lagged behind their earlier use in such traditionally strong computer areas as mathematics, science, and business. Perhaps because of the wide use of computers for word processing in business classes, the first uses of computers in language arts were primarily as word processing devices. At times attention has focused on the impact of the computer itself (Frase, 1987) in the writing process. When computers became more widely accepted and less intimidating, educators observed differential effects with various users and began to investigate (Baer, 1988; Powell, 1984). Emphasis has shifted from hardware and its effects on students to writing and how computers interact in this complex process (Auten, 1984; Dees, 1985; Wheeler, 1985).

In addition to questions regarding the impact of both hardware and software on the pedagogy of writing, other questions arose. Student attitudes concerning computer use (Johnson, 1988; Le, 1989; MacArthur, 1988) were studied. The effect of computers on student motivation has been studied by Lepper (1985) and by Seymour (1986). Studies by Daly (1978) and Faigley, Daly, and Witte (1981) dealt with student apprehension during the writing process. However, there is evidence that indeed a place exists for computers in teaching in general and in teaching writing specifically (Marcus, 1987a; Marcus, 1987b).

Revision has been identified as a desirable writing skill (Bean, 1983; Collier, 1983; Kurth, 1987; Monahan, 1984; Murray, 1978). The present study was the outgrowth of several informal projects with various teachers which explored ways of motivating students in writing classes to do more revision. Previously, students were reluctant to re-write papers that had been handwritten. The time and effort of re-writing was often beleaguered by new mistakes introduced during the re-writing process. Even when the students were provided with specific items to be corrected and when offered a higher grade upon correction and re-submission, students elected not to re-write, instead accepting a lower grade. Case studies demonstrated student willingness to re-write when provided with opportunity and facilities such as a word processing lab. These outcomes are similar to those described by Watt (1984). Microcomputers have been shown to be effective instruments of revision (Levin, & Boruta, 1984; Levin, Boruta, & Vasconcellos, 1983). In addition, computers have been shown to play a positive role in continuing motivation of students (Seymour, Sullivan, Story, & Mosley, 1987). In general, students like computers (McGarvey, 1986).

The purpose of the present study was to determine whether students preferred to have their compositions marked by their teachers or by a computer. After having a composition scored by a computer and another by their teachers, students were given a choice between the computer and teacher to score their third composition. Data were collected and analyzed on their choice, the reasons for it, and their attitudes toward the use of word processors. Pre-project and post-project questionnaires were used to assess student preferences and attitudes toward these variables.

Student choice of evaluation method was considered to be important because a diagnostic writing lab had been proposed for the English Department in the school in which the study was conducted. Students made their choice of evaluation method on the post-project questionnaire. Studies of continuing motivation (Herndon, 1987) have revealed that forced choice of a method of instruction or evaluation is a reliable indicator of future student preferences. A diagnostic computer program, MacProof®, was chosen from among those that were available. The MacProof® v 2.0 program was used to evaluate student papers and to provide written feedback to the students.

Method

Subjects

Subjects were 97 (36 male and 61 female) juniors and seniors, enrolled in four classes at a suburban high school in Arizona. One of the classes was for college-bound seniors, the other three were made up of average ability students. The Fifty-nine of the subjects (61%) reported their out of school use of computers to be zero hours per week, 14 (14%) less than one hour per week, 16 (17%) between one and 4 hours, and six (6%) more than four hours. The classes of two male instructors were chosen because of the instructors prior exposure to computer usage for writing and their positive orientations toward students.

Materials

Networked Apple IIe computers running AppleWorks® word processing software were used as work stations. For each assignment three writing skills were checked. These skills corresponded to a recently taught skill, a previously taught skill (more than three weeks prior), and a universal skill such as spelling.

On exercise one the three areas of concentration were vague terms, forms of the "be" verb, and spelling. On exercise two the three areas of concentration were, punctuation, confused terms, and spelling.

The computer took each of the files that the students had entered and printed it double spaced. The files for the computer marked compositions were further processed with MacProof®. By selecting each of the three skills to be checked from a menu of twenty-one possible areas and having the computer print out a list of errors. Depending on the type of check selected, the printout would correspond to one of the following: a list of misspelled words, or a questioned item, such as a vague term, highlighted by boldfacing within a sentence fragment, coupled with a short 3-5 line explanation of why the word is vague, along with suggestions on how to improve the sentence. If there were no mistakes for a given skill, there was no page printed. Separate printouts were provided for each skill checked and stapled to the corresponding composition printout.

Teachers wrote directly on the student printouts from the teacher marked group using checkmarks and comments normally used by that teacher. In addition to the three designated skills the teachers often marked other areas and added personalized comments.

Procedures

Before starting the project, students were familiarized with the operation of the computer and AppleWorks® word processing program, including data entry and simple editing procedures, and with the procedures for saving and retrieving files on a network. An existing microcomputer lab in the Mathematics Department was used with a separate off-line process to evaluate the student papers. Prior to the first writing assignment, the teacher administered a pre-project questionnaire dealing with prior computer experience and attitudes toward computer usage to all students. The mechanics of saving and retrieving files from a network was also reviewed.

Upon completion of the pre-project questionnaire, the students were told that they would be part of a study on the use of writing labs and that the project would consist of three exercises, with one-half of the papers randomly assigned to either teacher-marked or computer-marked treatments on exercise one. On the second exercise the two groups would be switched so that all students experienced both methods of evaluation.

For each of the three exercises the topic was presented to the students three days before going to the computer lab. The compositions were to be approximately 250-350 words in length and composed at the terminal, although students were encouraged to plan out their writing ahead of time, using pre-writing activities such as outlining and organizing as practiced in the usual class activities. On the designated day, the whole class was taken to the lab to enter their compositions into the word processor. On the first exercise students did not know which marking method would be used on their papers. Student files were saved to a central storage device from which copies of the files were ported to a Macintosh computer for analysis using the MacProof® program. Marked copies were returned to students for each assignment within two class days. The three exercises were spaced approximately 8-10 school days apart, depending on lab availability and class readiness.

Students selected either the teacher or the computer as the evaluator of their draft copy on the third written composition. The selection took place after the students entered their composition into the computer. The instructor noted which method each student wished to have applied to the material, and the papers were marked accordingly.

Criterion Measures

The criterion measure was a four-item questionnaire administered to all students at the conclusion of the study. The four questionnaire items asked students (1) Which evaluation method did you chose on cycle three? (2) Word processors make writing easier - (Yes or No)? (3) If a writing lab were available would you use a computerized style, grammar, and spelling checker for assignments? and, (4) What made you choose either the computer or teacher evaluation for the third cycle?

Post-Project Questionnaire responses to "What made you choose either the computer or teacher evaluation" were classified by the experimenter as pro or con teacher and pro or con computer.

A five-item Pre-Project Questionnaire was also administered to all students. The Pre-Project Questionnaire dealt with student attitudes toward computers and student use of and experience with computers and word processing, as well as with student attitudes toward teacher grading of papers and a student self-ranking of writing ability.

Data analysis

All questionnaire responses were analyzed using Chi-square.

Results

Eighty-four of the 97 students (87%) chose to have the teacher mark their third composition and 13 students (13%) chose to have the computer mark it. Chi-square analysis revealed that this preference for teacher over computer evaluation was statistically significant, χ^2 (1, N=97) = 51.97, $p<.001$.

Student responses to the question "What made you choose either the computer or teacher evaluation for the third cycle [exercise]?" were classified into common categories for ease of understanding and reporting.

Students wrote a total of 70 pro-teacher statements and 18 pro-computer statements. Students also wrote 16 negative statements about the computer, but none about the teachers. The frequency of each type of response is shown in Table 1. It can be seen from the table that the most frequent pro-teacher responses were personal help (24 responses) and ease of understanding (23 responses). Other frequent pro-teacher responses were that the teacher checked additional areas (15 responses) and that the teacher is the ultimate grader (12 responses). The most frequent pro-computer response (7 students or 7%) was that it catches more mistakes than the teacher, and the most common con-computer response was that it catches too many mistakes (8 responses). There were no con-teacher responses.

PLEASE INSERT TABLE 1 ABOUT HERE

Responses to several other questions on the Pre-Project Questionnaire and Post-Project Questionnaire are summarized in Table 2. On the Pre-Project Questionnaire 83 of the 97 students (86%) reported that the liked using word processors and 14 (14%) reported that they did not. Seventy-one students (73%) responded that they thought typed papers received higher grades than handwritten ones, whereas 26 (27%) indicated they did not think so. The difference between teachers on this item was not statistically significant.

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Table 1

Student Reasons for Choice of Teacher or Computer

Pro Teacher	Number
Personal help	24
Easier to understand	23
Additional areas checked (style etc.)	15
Ultimate grader of end product	12
Specific, in place comments	7
Alive/human grader	4
Pro Computer	
Thorough - catches more mistakes than teacher	7
Lists mistakes	5
Efficient	5
Easy	4
Con Computer	
Too many mistakes (non-mistakes listed)	8
Too confusing	5
Con Teacher	
None	

Table 2
Student Attitudes

Question	Yes	No
Pre-3 Like using word-processors	83 (86%)	14 (14%)
Pre-4 Higher grades - typed papers	71 (73%)	26 (27%)
Post-2 Word processors make writing easier	90 (93%)	7 (7%)
Post-3 Use lab (w/more features) if available	76 (78%)	21 (22%)
Male	25 (69%)	11 (31%)
Female	51 (84%)	10 (16%)

On the Post-Project Questionnaire, 90 students (93%) responded that they thought word processors make writing easier, whereas only seven students thought they did not. Seventy-six students (78%) reported that they would use a writing lab if one were available, and 21 students (22%) reported that they would not. A significantly higher number of girls (84%) than boys (69%) reported that they would use the writing lab, χ^2 (1, N=97) = 16.7, $p<.005$.

Discussion

The primary result of this study strongly favored teacher marking of student compositions over computer marking. Students liked the more personal nature of the feedback from the teachers. They also preferred teacher marking because it was easier to understand, perhaps because the nature of the process enables the teacher to provide more specific comments at the relevant points in the manuscript whereas the computer feedback is more general and on a separate page. Many students also liked the fact that the teachers checked additional areas than those emphasized for the particular composition or preferred teacher marking because the teacher was their "writing audience" - - the ultimate grader. Several students liked the computer for its thoroughness in catching mistakes; whereas several others thought it was too thorough, catching too many mistakes or some non-mistakes.

Although students preferred teacher marking over computer marking, data from the study indicate very positive student attitudes toward the use of computers for preparing their compositions. Ninety-three percent of the students thought that word processors made writing easier.

Seventy-three percent of the students indicated that they thought typed papers would receive higher grades over handwritten papers. During the study all of the student papers were mechanically reproduced as a result of using word processors, and the instructors commented that mechanical printing made the papers easier and faster to read.

Overall, 78% of the students responded that they would use a writing lab if one were available. Since the completion of this project, a twenty-one station Macintosh equipped writing lab has been installed at the school. Personal observation and network server logs indicate that the lab is busy before, during, and after school. There was a difference by sex on using a writing lab with 84% of the females indicating that they would use a lab while 69% of the males favoring use of a lab.

Personal help was the reason given most frequently by students for choosing teacher marking. Examination of teacher-marked papers revealed that both teachers often used students' first names when writing comments on the papers. The teachers often included references to other personal matters or events, and may thereby have increased students' feelings of personalization. Of course, just the more personal nature of marking by a human being rather than a computer may also contribute to those feelings.

Personalization of instruction can have an important effect on student learning (Anand, & Ross, 1987; Ross, & Anand, 1987). Other researchers (López, 1989) have generated personalized instructional programs by computer that produced better student achievement and/or attitudes than non-personalized programs. Personalization in these studies was accomplished by having each student complete an inventory of interests, including the names of friends, which were then incorporated into individualized learning materials for each student. Although these studies were conducted in the areas of math and logic, similar effects may have occurred with the two teachers in this study when they used the students' first names and personalized events when adding comments to the marked papers.

Personalization of feedback by computer on complex tasks may be more difficult to accomplish efficiently than personalization of initial instruction. Merely inserting the student's name, form letter style, into the computer analysis of the composition would probably not have the same effect as the teacher's personalized comments written directly on the students' papers. Despite advances in computer systems, it would seem that when dealing with student writing the teacher can react more appropriately to student needs, pinpointing problems and suggesting specific remedies, while maintaining rapport with the student.

The teachers were free to provide other types of feedback to the students on topics such as overall style. The students noted this in their questionnaire responses. In post-project interviews students commented that they were writing to the teacher's requirements. The teacher was the grader of the paper, and that if the teacher pointed out areas that needed additional work, this was all that needed fixing. Papers would receive a higher grade if the student fixed what the teacher marked. These facts should diminish any fears that when students use computers with proofing aids in language arts classes ". . . there won't be anything left to correct" (C. Crowe, personal communication, 1985).

Students also liked the way that the teacher comments were placed directly on their papers, very near the problem. Students commented that they liked the grader to be alive and/or human. Other students commented that they thought teachers stopped checking after four or five mistakes. Some noted that the computer was exhaustive in finding all mistakes.

Several style-checker programs are currently available. Most are specific to a particular type of computer. MacProof® v 2.0, the checker program used in this study, was compatible within the family of classroom computers available at the school.

The two teachers selected to participate in the study were young (24-26 years) male teachers recognized for their ability to work well with students. The popularity of these two teachers, familiarity with students, and the use of personalized remarks on papers may have influenced the selection made by students.

The teachers liked having the computer provide rudimentary analyses of the student papers in basic skills such as spelling, punctuation, vague terms and other areas, which freed up the teacher to work with students on "idea/creative" areas of the assignments.

In her chapter on Writing, Ellen Gagné (1985) points out that unskilled writers spend much of their time trying to avoid mechanical mistakes. Proofing programs allow writers to concentrate more on communicating well, leaving mechanics to be checked prior to the final draft. When the students are working at the computer, entering the composition, the teachers were able to circulate amongst the students, providing individual attention. Butler (1985) would see this as highly supportive of many of the features listed by Hairston (1982) as characteristics of the new composition paradigm.

One observation from the study was that teacher-marking and computer-checking in combination may be the most effective way to mark compositions. Based on the student selection of the teacher as grader and the teacher acceptance of the time saving/error catching capabilities of the computer program an effective combination would have both the teacher and the computer available to students. The computer serving the student as a tool in the writing, editing, and revising cycle, while the teacher provides overall instruction and personalized marking of papers. Version 3.2 of the MacProof® program operates as an interactive desk accessory. Students would be encouraged to pre-check their own papers with the help of the computer to eliminate grammatical mistakes, allowing teachers to spend more time helping the students write better.

Additional research is needed to test the effectiveness of combining teacher personalization of feedback with the analytic capabilities of existing computer software. Combinations of direct student access of composition mechanics coupled with degrees of teacher involvement during the revision process could yield guidelines on how students can best be served by the availability of writing laboratories and computers.

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Title:

Determining Trends and Issues in Educational Technology through Content Analysis

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Purpose of This Study

The Educational Resources Information Center (ERIC) attempts to generate syntheses of the literature of various academic disciplines and other areas that contribute to the field of Education. The purpose of this publication is to provide some indication as to where the field of educational technology is going. The identification of emerging trends and issues is a first step in this endeavor.

The ERIC Clearinghouse on Information Resources specializes in the areas of educational technology and library/information science. One objective of this study is to provide an indication of the emerging trends and issues in the field of educational technology. A parallel study of trends and issues in library and information science was conducted at the same time using the same methodology. Findings from that study are reported in IR No. 81, Trends and Issues in Library and Information Science 1988, which is available from the ERIC Clearinghouse on Information Resources. Because the sample of the literature that was included in this study was drawn from a single-year period (October 1987-September 1988), the ability to verify trends is somewhat limited. Another objective of this particular study, then, is to develop a database that will serve as a reference point for trends in the area of education technology to facilitate their identification and analysis in the future. A third objective is to develop a methodology for the identification of emerging trends that would allow a large number of documents to be reviewed in a reasonably short period of time without relying too heavily on purely quantitative forms of analysis.

Content Analysis: Some Background

Content analysis was used to determine the emerging trends and issues relevant to educational technology. A trend is considered to be a cumulative indicator of activities or products that shows direction. An issue is considered to be a problem or a question for which there are multiple points of view. It is important to note that a trend may be considered by some to be an issue. As a problem or question develops within an academic field, it may be considered an issue. The distinction between these two concepts is not as clear as one might like it to be.

Content analysis is intended to be a method for the objective and systematic collection of pre-specified data for the purpose of identifying the special characteristics of those data (Carney, 1972). It is a broad concept that can be used in any attempt to practice research or science. Whenever symbolic action or communication is the subject of investigation, the analysis of content is involved (Janowitz, 1976).

Not all content analysis is the same: there are both quantitative and qualitative strains of content analysis. A common form of the qualitative type of content analysis is conceptual analysis, i.e., the investigation of the use and meaning of particular words. A common type of quantitative content analysis is the measurement of the length of articles that deal with a predetermined topic. A tabulation of the results of either of these forms of content analysis is required in order to make any inferences about trends. Examples of the use of content analysis as a methodology have appeared in both the popular and the academic press. John Naisbett's Megatrends (1982) identified 10 trends that he thinks will become influential in our lives.

Morris Janowitz (1976) outlines the application of content analysis to determine socio-political trends from a sampling of our nation's newspapers.

Reviews of the advantages, limitations, and features of content analysis can be found in Janowitz (1976), Carney (1972), and Hosti (1969).

Content Analysis in This Study

The professional literature of a field indicates the concerns, inquiries, and research that are important to that field. Such is the case with the literature of educational technology. It was decided that a review of the professional literature of educational technology would reveal the ideas that were of importance to the field. Through this process it was hoped that indications could be derived about the direction (emerging trends and issues) of the field. The basic idea behind this study was that if one could classify and tabulate pre-selected writings based on interpretations of the authors' purpose it would be possible to indicate current directions in the field.

In order to achieve this end, it was determined that a substantial number of source items would have to be reviewed. Because this study was primarily concerned with the number of times that a topic was discussed (as opposed to the length of the discussion or the particular use of the concepts involved in the discussion), and given the resource constraints (limited time and manpower), it was decided that a content analysis would be the appropriate data collection technique, but that a "hybrid" form of content analysis would have to be developed for the purpose of this study.

It was imperative that the data collection teams be able to review and classify sources efficiently and effectively, while avoiding the pitfall of playing "fast and loose" with the data. The development of this "hybrid" form of content analysis can be outlined as follows:

- The conceptualization of the recording units and categories.
- The determination of the sources to be reviewed.
- The specification of the data collection procedures.
- The analysis of the data.

It is reasonable to state that the vast majority of content analyses that are concerned with determining trends must somehow address these steps. However, these particular tasks do not always occur in the order in which they were performed in this study. A reordering of tasks can be the difference between inductive and deductive studies. In this study we use a deductive methodology. Because of the nature of the content that is specific to each field in trends research, there is no one right way to do content trends analysis. Hence, by necessity, it is a hybrid methodology. It is important to acknowledge that each type of content analysis has its own advantages.

Conceptual Categories into Operational Definitions

The general content categories that were used in this study were based on the concept of the functions performed by media personnel that were discussed by Chisholm and Ely in 1976. This conceptual scheme reflects the definition of educational technology put forth by the Association for Educational Communications and Technology (1977). These general areas were thought to be indicative of the field of educational technology: Personnel, Management, The Field, Instructional Processes, Information Services, Technical Developments, and Research and Theory. The content categories were determined before the study began rather than during the review of the data sources. In this sense the categories were "imposed" upon the study rather than generated in a more inductive fashion. This conscious decision was based on the need for efficiency in the data collection process. After the general content categories had been identified, subcategories were specified. Some were added later during the data collection process. The specification of these components was based on a thorough knowledge of the literature and extensive experience in professional practice.

An example of one of the conceptual categories is the function of "management." The broad concept of management was operationalized by specifying the following tasks: planning, budgeting, diffusion and implementation, logistics, operations, and facilities.

Two instruments had to be created for this study. The primary instrument allowed reviewers to record both the source of the data and the category into which the source had been classified. The second instrument served as a tally and comment sheet for each item collected and classified on the primary instrument.

Content Source Units

Journal articles, dissertation abstracts, ERIC documents, and professional conference programs were chosen as the content units because they provide a current record of issues and topics that leaders in the field of educational technology have acknowledged as important.

The analysis of the content in professional journal articles and dissertation abstracts is not new to research in the area of educational technology.

Torkelson (1978) reviewed 25 years of the Audiovisual Communications Review (AVCR) as part of an investigation to determine which issues had had the strongest impact on the development of educational technology as a professional field. His article covers his AVCR findings as well as trends and areas identified for further study.

Mayo (1976) analyzed AVCR journals published in a 20-year period between 1953 and 1972 for a doctoral dissertation. The study showed several trends within the context of the journals. These included an increase in the sophistication of research design, the methodology, and the statistical analysis.

Lard (1979) reviewed two journals, Audiovisual Communications Review (AVCR) and Audiovisual Instruction (AVI), the official journals of the AECT. The scope of her study also included the abstracts of dissertations from five universities with major doctoral programs in the field of educational technology. This study revealed that there were three distinct paradigms operating in the field of educational technology during the 21-year period covered by the study: the media movement, systems theory, and behavioral technology.

The journals selected for analysis in this study were those that had been identified as five of the "most influential" professional journals by Moore in 1981 and Moore and Braden in 1987: The Journal of Instructional Development, The Educational Communications and Technology Journal (formerly AVCR), Educational Technology, TechTrends, and The British Journal of Educational Technology.

The dissertations that were included in this study were produced at the universities that were identified by Moore in 1981 and Moore and Braden in 1988 as being the "most prestigious institutions" in the field of instructional technology: Arizona State University, Florida State University, Indiana University, Syracuse University, and the University of Southern California.

Conference programs and ERIC documents were added to this particular study in order to broaden the scope of the content to be analyzed. It appeared that conference programs would reveal the latest developments in the field of educational technology because conference presentations usually discuss the most recent findings of current research and development efforts. Three professional conference programs, the Association for Educational Communications and Technology (AECT), the National Society for Performance and Instruction (NSPI), and the Educational Technology International Conference (ETIC) were included in the database for this study. The AECT and NSPI programs were included here because these two organizations are considered to be the two most prestigious organizations in the area of educational technology in the United States. The AECT conference is considered to be the one for those interested in the academic aspects of the field of educational technology, while the NSPI conference is considered to be the one that is attended by practitioners of educational technology. The ETIC conference program was included in this study to ensure a more global outlook on the emerging trends and issues in the field.

ERIC documents were included in the scope of this inquiry since the materials entered in the ERIC database represent a cross-section of the contemporary literature of educational technology. Following the basic premise of Webb (1966), the research team believed that a multiple operational approach should be emulated.

The research team felt that it could have an increased level of confidence in its analysis if it increased the scope and breadth of the data included in the study.

Data Collection Procedures

The data classification and tabulation instruments were tested for their functionality. This was done by asking prospective data collectors to use the instrument to review the same three articles from one professional journal. Particular attention was paid to the conceptual clarity of the content areas, and efforts were made to identify ambiguities and confusing elements within the instruments that might mislead the data collectors into generating erroneous classifications. The graphic design of the instruments was checked to insure the efficiency and the effectiveness of the data recording process.

A training session was held for the data collectors, who were all graduate students at Syracuse University. This session was designed to teach them how to:

- Identify the purpose of an article by reading the introduction, abstract and concluding statement.
- Use the data source and classification instrument.
- Use the tabulation and comment instrument.
- Locate the data sources.

The ability of the data collectors to meet these four objectives were demonstrated by a test for inter-rater reliability.

After a period of one week the data collectors met and compared the results of their interpretations of the articles from three different professional journals. The Pearson Correlation Coefficient (r) that had been calculated for the pairs of data generated by the collectors slightly exceeded r=0.8. To insure further reliability, it was decided that each data collector would designate two possible categories for each of the journal articles, a primary choice and a secondary choice. The employment of this technique virtually eliminated cases of non-agreement among the data collectors. Inter-rater reliability was virtually assured as data collectors discussed those cases where they had disagreed until an agreement could be reached.

At the conclusion of the data source recording and classification phase of the study, the data collectors tabulated the results. They reported the results of all of the dissertations on one tabulation instrument for analysis. Each of the five professional journals and each of the three conference programs that were reviewed was reported separately, as were monthly entries in the ERIC index, Resources in Education (RIE). This style of reporting allowed for cross-source analysis.

Major reports and position papers published within the time period of the study and personal observations from professional participation in national and international events were also used to provide further input and clarification.

Limitations to the Study

There are a number of limitations to this study. First, as a form of content analysis, the study is a "hybrid." It does not enjoy the advantages of conceptual analysis, i.e., the inquiry into the use and meaning of particular terms that have a bearing on the field of educational technology. Second, it has no quantitative base other than that of tabulation. The methodology did not reveal the depth of the particular content that was used or analyzed in the sources. Third, the decision to use sources that have no precedent in content analysis (e.g., conference programs) raises questions about the data sources that were used in the study. Fourth, there is the possibility that certain items that were reviewed as source data were "specialty items." Special issues of a particular journal or a conference dedicated to a particular theme could "skew" the results of a study. Fifth, it is difficult to make statements about trends based on the data gathered in a single year since there is no earlier referent. Finally, the attempt to emulate the multiple operational model of analysis was not a true one. Since multiple operationalism is an attempt to bring several different methodologies to bear on a particular question or concern, this study could be considered as a cross-methodological, meta-analysis. Although attention was given to increasing and varying the amount and types of data sources used to analyze trends and issues in the field of educational technology, the study used a single methodology.

Recommendations for the Future

It is more than an exercise in humility to acknowledge the limitations of a particular study: it is intellectual honesty. Three goals were set forth at the beginning of this study. The first was to provide an indication of the emerging trends and issues in the field of educational technology. The difficulty of recognizing trends based on data gathered from a relatively short time span has already been mentioned. But certainly the number and variety of sources utilized make the analysis provided here more than an "educated guess." The second goal of this study was to develop a data source that will serve as a baseline so that trends in the field of educational technology can be more easily recognized in the future. It is much easier to have confidence in having met this second goal. The data that have been gathered during the course of this study will presumably be used by future analysts, as they provide a tabulation of the professional discussions about what comprised the field of educational technology in 1987-88. The third goal of this study was to develop a methodology that will allow an expedient review of the professional literature of the field of educational technology. Here, too, it is easy to feel confident about having met the goal; however, there is still much to be done in this regard. The instruments require some refinement. Data sources must be reconsidered. Integration of other types of trend and issue analysis into this methodology should be addressed. Webb, Campbell, Schwartz, and Sechrest recommended the technique of multiple operationalism, asserting that "once an idea has been confirmed by two or more in dependent measuring processes the uncertainty of its interpretation will have been greatly reduced" (1966, p.3). Resource and time constraints precluded the use of other data-gathering techniques and contribute to limitations of this study. The decision to broaden the scope and number of content sources sampled, however, increases the level of confidence that can be placed in the data. These are questions that must be faced at the beginning of any such trend analysis. Surely more such questions will emerge. Upon the completion of this phase of this infinite enterprise one can only think that long journeys start with small steps.

Major Trends Identified by the Study

Design, development, and evaluation of instructional materials and procedures is a primary concern among practitioners in the field of educational technology.

A large portion of the educational technology literature is about the design, development, and evaluation of instructional materials. Issues in design include the application of cognitive psychology, such as in helping learners to conceptualize unfamiliar content; semiotics and the effects of message configuration characteristics, such as text design, text density, visual design, and use of symbol systems; and the effects of media use on motivation, including learner interest, achievement, and attitude development. Development includes such activities as needs assessment, course development, and product development. Finally, evaluation is concerned with measures and procedures for determining program effectiveness. Related to this is a call for better procedures for evaluating computer-assisted instruction software and software evaluation databases that are accessible to individuals.

Professional education for teachers in the use of educational technology principles and practices is seen as a basic need for present and future professional service.

Literature in this area is directed both at professional specialists within the field of educational technology and at individuals who teach. Currently, the emphasis appears to be on the teacher/instructor. The basic question is, "What competencies do teachers/instructors need to use technology effectively with their learners?" The assumption is that all classroom presenters should be using media and technology but are not, or that they are using it in less than optimal ways. Much of the literature discusses the use of computers and microcomputers by classroom teachers, and it emphasizes the need for teacher training in the area of information technology rather than educational technology or library instruction. This subtle difference is indicative of the gradual blending of educational media and technology with library and information science in the elementary and secondary schools.

Distance education is becoming a significant instructional delivery system that uses technological means to reach its goals.

Interest in distance education is stimulated in part by concerns over equity of access in the face of shortages of qualified elementary and secondary school teachers. Distance learning protocols have developed in direct response to real teaching/learning problems. Distance education offers practicable solutions to shortages of resources and teaching personnel. To prepare material for delivery requires a systematic approach to instructional design and a concern for the individual student rather than for group teaching. Much of the literature about distance education refers to the use of various telecommunications systems to provide optimum participation by the learners (National Governors' Association, 1988).

The computer is the dominant medium in the field of educational technology.

Statistics show tremendous growth in school use of computers in recent years (Quality Education Data, 1988). It is no longer just the computer-established secondary schools that lead the field; now more than half of U.S. elementary schools have enough computers to provide at least one for every two classrooms. Elementary schools use their micros primarily to supplement lessons with basic skills exercises and opportunities for drill and practice. In secondary schools, the micros are used primarily for teaching formal computer literacy (Talmis, 1988). Teachers express interest in having publishers develop software that teaches problem-solving skills and higher order thinking skills. While the literature reflects the growing enthusiasm for school computer use, it also shows continuing criticism of software quality.

After computers, telecommunications and video are emerging as major media delivery systems.

The apparent preoccupation of educators with computers often overshadows the increasing interest in telecommunications and video. While schools continue to use the traditional audiovisual equipment such as films, filmstrips, slides, audiotape recordings, and overhead transparencies in a more-or-less routine fashion, new development seems to be with video in the classroom for large group instruction, and telecommunications for individuals and small groups within the school and in distance education programs. The Quality Education Data study (1988) notes that over 90% of the schools in the U.S. are using videocassette recorders, while in 1983 only 30% of the schools used VCRs.

The role of the educational technologist is unclear and varies from location to location.

There are very few professionals who actually hold the title of "educational technologist." They are usually represented by such titles as: media specialist, media coordinator, or library media specialist; sometimes they are the director, supervisor, or coordinator of educational media, instructional media, or communications. Newer and more specific titles are emerging, including microcomputer coordinator, instructional computer teacher, or specialist in educational computing. Although it is now likely that most large schools and school districts have one or more persons who are responsible for the administrative, logistic, and instructional aspects of instructional media (or, in some cases, just computers), these professionals are assuming such roles from a variety of previous positions and with varying types of education and experience. The question that seems to underlie all of the ambiguity is, "What competencies are required of individuals who are designated to be the educational technologists?"

Case studies serve as models to follow in the implementation of educational technology applications.

People who study the adoption of educational innovations know that one of the most powerful factors affecting adoption is evidence that an innovation has worked in a situation similar to the one where it is being considered. Although they do not carry much information in the way of theory, research, or development, case studies serve as "lighthouses" or "pilots" for other institutions or organizations. The value of case studies in the organization and management of educational technology is demonstrated in the Office of Technology Assessment report, Power On! (1988). Spread throughout this document are 29 comprehensive case studies of technology use in schools. Such reports as New York State Teacher Resource Centers and Electronic Networking, Writing by Hand/Writing with a Wordprocessor, and Software Evaluation in California help educational practitioners see how others have successfully used technology to solve specific problems of teaching and learning.

The field of educational technology is concerned about its status as a profession.

Much of the journal literature is about educational technology as a profession, discussing such issues as status, ethics, legal aspects, history, and future developments of the field. It is obvious that practitioners of educational technology are concerned about their professional development and identity. They are attempting to understand who they are, what they should be doing, and how others view them. Such concerns are typical among individuals who feel that they are in an emerging profession without the tradition of an established discipline. It is a generally healthy trend which will probably be evident for many years to come.

Educational technology principles, products, and practices are just beginning to be integrated into courses and curricula.

The history of media in education is one of enrichment or enhancement. Not surprisingly, some of the literature examines the ways in which educational technology and media specialists provide support to teachers/instructors to improve their effectiveness. There is, however, increasing interest in media specialists as curriculum consultants. Komoski (1987) argues that schools must take the initiative and begin designing curricula that will provide teachers and students with a variety of options and strategies for achieving curriculum goals. To this end, he describes the Integrated

Instructional Information Resource, a group of broadly accessible, electronically searchable, and interrelatable databases that are designed to assist educators in developing "opened-out" curricula. Information Power (AASL & AECT, 1988) states that the library media specialist must develop a new, multi-faceted role as information specialist, teacher, and instructional consultant, and offers guidance for assuming these roles.

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Title:

A Hypermedia Lesson about 1875-1885 Costume: Cognitive Style, Perceptual Modes, Anxiety, Attitude, and Achievement

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A Hypermedia Lesson about 1875-1885 Costume: Cognitive Style, Perceptual Modes, Anxiety, Attitude, and Achievement

Cognitive Style

Cognitive style is the person's characteristic manner of receiving, processing, storing, and retrieving information (Messick, 1969). Cognitive styles are consistent individual differences in mentally organizing and processing both information and experience.

One of the problems associated with the teaching-learning process is related to determining how each learner acquires, stores, and recalls information effectively. Knowing an individual's learning style can be useful if teachers and students are aware of a student's weaknesses and strengths. Through training, a student's cognitive style can become modified and adapted (Keefe, 1985). Instruction can help individuals augment their use of perceptual modes. Perceptual alternatives such as visual images, audible statements, and verbal text may affect learners' abilities to assimilate, retain, and use information.

Cognitive style studies have historically been thought to have little practical importance for instructional designers and teachers. This is primarily because the teacher is faced with the need to design individual instruction.

Individual instruction is feasible with the use of technology. The use of hypermedia has the potential to meet individual learning style needs within one program. Hypercard Macintosh programming allows information to be presented in various forms as text, graphics, motion, animation, voice, and still frames.

Learning Style Instruments

Researchers have attempted to measure students' information-processing habits by using learning style tests. Generally, these instruments have been quite limited in their ability to measure these complex behaviors. For instance, the Group Embedded Figures Test (GEFT), developed by Witkin (1950) has been widely used to assess one cognitive dimension: field independence vs. dependence (Keefe, 1987). One-dimensional learning style instruments led to the development of multi-dimensional learning style tests, providing a more comprehensive assessment of learning style. A multi-dimensional test, the National Association of Secondary School Principals' (NASSP) Learning Style Profile (LSP) includes twenty-three independent constructs within three areas: cognitive style, affective style, and physiological style (Keefe and Monk, 1988). Within the cognitive component, nine general information-processing dimensions are included: analytic, spatial, discrimination, categorization, sequential, memory skills, visual perception, auditory perception, and emotive response.

Hypercard and Videodisc

Instruction can be designed to accommodate individual differences. The interactive videodisc and computer system possesses some distinct characteristics that permit multiple modes of delivering information. The videodisc and computer lesson is able to deliver information in random order, at a variable pace, with multiple sensory learning.

Instruction via videodisc and computer allows students to gather information from various modes (visual, verbal, audible). Hypercard programs enable learners to control a lesson giving the students the power to choose the sequence, pace, perceptual mode, and the content of the lesson. Hypercard has a feature called buttons which are sensitive areas on the page units of the computer screen. When the Macintosh mouse is clicked on a button, a predetermined action is performed, such as showing a videodisc image, or playing a pre-recorded narration. Since computers can accurately count each selection chosen by a learner, computers are a viable way to investigate individuals' information-processing habits.

An interactive videodisc-Hypercard computer lesson, A Look Backward: An Encounter with Late Victorian Fashion was designed to allow students to choose from three modes of receiving information: seeing, hearing, and reading. The computer screen shows the text and the commands that allow the learner to gain access to information. A second screen, a TV monitor, displays a video image.

The current research attempted to discover which perceptual modes students used to receive new information. Written words, visual images, and spoken words are included in the study.

Computer Attitude

Keefe (1979) defined affective styles as motivational processes that are the learners' typical modes of directing and sustaining behavior. A computer attitude test, Beliefs About Computers Scale (BACS), was developed by Ellsworth and Bowman (1982). Computer attitude referred to a person's feelings about societal use and individual use of computers. The test consisted of 17 statements which are rated on a Likert scale of one to six.

Computer Anxiety

Computer anxiety is defined as the fear or apprehension felt by an individual when using computers, or when considering the possibilities of using a computer (Simonson, et. al., 1987). A Computer Anxiety Index (CAIN) was designed to identify students who had computer-related anxieties, so that steps could be taken to reduce anxiety and improve achievement.

Maurer and Simonson (1984) reported that an individual with high anxiety would avoid computers, use computers with great caution, and talk negatively about computers and computing. According to Simes and Sirky (1985), some people experience stress during an interactive lesson. Anxiety affects performance in cognitive processes.

Purpose

The purpose of this study was to obtain students' cognitive style profiles and obtain a record of students' use of three information modes during a hypermedia lesson. This study examined relationships among 1) nine dimensions of cognitive style as measured by a standarized learning style test, 2) students' use of three information modes (visual images, written text, and audible descriptions) during a hypermedia lesson, 3) computer attitude, 4) computer anxiety, and 5) achievement.

Research Questions

1. What are the dominant dimensions of cognitive learning style for the total sample and two subgroups: college students in teacher education classes and textiles and clothing classes?

2. What are the relationships among these variables:
   1) cognitive learning style, 2) use of information modes in a hypermedia program, 3) computer anxiety, 4) computer attitude, 5) prior knowledge, and 6) achievement?

Research Design

A descriptive and correlational design was used for the study. Fifteen variables were examined, including cognitive style dimensions, prior knowledge and achievement of 1875-1885 costume, computer anxiety and computer attitude (both before and after the lesson).

Subjects were seventy-nine undergraduate students enrolled in junior year classes: textiles and clothing, and teacher education. Forty-two students were in the textiles and clothing class and thirty-seven students were in the teacher education class.

Five instruments were used to collect data: 1) NASSP Learning Style Profile, 2) A Look Backward: Victorian Fashions, a hypermedia program, 3) CAIN, 4) BACS, and 5) achievement tests. Valid and reliable measures were used.

Students completed the NASSP Learning Style Profile test which was used to assess cognitive and perceptual dimensions of learning. These dimensions diagnosed strengths and weakness of each individual's general approach to processing information. The test consisted of cognitive tasks to complete rather than Likert scale ratings. The performance on the NASSP Learning Style Profile was compared to their performance in the hypermedia program.

The perceptual response subscales: visual, auditory, and emotive measure students' initial reactions to a list of 20 words by mentally "seeing" a picture (visual); by mentally "hearing" the word (auditory); or by sensing an emotive (emotive). The emotional response may involve a physical reaction, such as taking notes, or an initial positive or negative attitude toward the word. The relationship between cognition and emotion is being examined by researchers since the "meaningfulness" of learning may be connected with affective and psychological aspects.

Each subject scheduled a one-hour session to use the hypermedia lesson, A Look Backward: Victorian Fashions. The Hypercard computer and videodisc lesson enabled the subjects to choose among three information modes: visual, verbal, and auditory information. Visual images were available in both line drawings and detailed illustrations from a videodisc. Verbal descriptions about each costume were written and read on the computer screen. Audible descriptions of each costume could be heard through the speakers of the Macintosh computer. Objectives were given and the students chose modes of information to accomplish them.

An important feature of the hypermedia lesson was its ability to track students' progress. Hypercard counted the students' choices made during the program; 1) visual images, 2) text descriptions, and 3) audio descriptions.

Students completed tests: 1) the Computer Anxiety Index (CAIN), Beliefs About Computer Scale (BACS), and 3) achievement tests. These tests were given before and after the students used the hypermedia program. The CAIN test was selected to measure computer anxiety. The twenty-six item survey is reliable and valid (Simonson et al., 1987). Normative data was available, the average score was 60.23 (Simonson et al., 1987).

The computer attitude test, BACS, (Ellsworth & Bowman, 1982) was used also. It had a reliability of 0.77.

Results

Descriptive statistics, t-tests, and correlations were calculated. T-tests were used to compare the differences between students enrolled in the two classes. The Pearson's product moment correlation was used to identify relationships between variables.

Results and Interpretation Related to Research Question #1

Students' received a score for each of the nine cognitive style dimensions as measured by the NASSP Learning Style Profile (see Table 1). The subjects average scores showed analytic, spatial, and categorization skills as the strongest. The weakest skills were audio response and discrimination skills. Nine t-tests were calculated to determine differences between the teacher education and textiles and clothing classes' scores. Significant differences were found for two dimensions: sequential processing and emotive. The teacher education class had stronger sequential processing skills than the textiles and clothing class. However, the textiles and clothing class had stronger emotive responses than the teacher education.

Pearson correlation coefficients were calculated for each of the nine cognitive dimensions (see Table 2) and the results did not indicate that these dimensions duplicated one another. The results signify that the nine dimensions are independent constructs.

Results and Interpretation Related to Research Question #2

Descriptive Statistics

Information modes Students chose among three modes (visual images, auditory statements, and written descriptions) in order to receive information while using the hypermedia program. The computer counted the students' choices of each of these information modes. The frequency counts were changed to percentages. The results of their choices are given in the following paragraphs.

Use of Visual Images Statistical results showed that students' average percentage for choosing visual images was 55.89 % of the time. Visual images were chosen more often than either text or audio modes. The teacher education class used significantly ($p<.03$) more visual images than the textiles and clothing class (see table 3).

Use of Text Statistical results showed that students chose written descriptions in the hypermedia program on an average of 29.44% of the total selections. No significant differences were found between the teacher education and textiles and clothing students' use of text in the lesson.

Use of Audio Students used audio the least of the three information modes. Audio was used 14.67 % of the time. No significant differences occurred between the two groups of subjects.

Computer Anxiety The results of the CAIN were an average score of 60.25 for the first test and 59.53 for the re-test. The analysis indicated significant statistical differences ($p<.0003$) between the teacher education and textiles and clothing classes' level of anxiety. Little change occurred between the first and second administration of the test. The first test averages were 51.86 and 67.47 for teacher education and textiles and clothing, respectively. A higher score indicated a higher level of computer anxiety. These scores were compared to the norm score 62.33 (Simonson et al., 1987). The textiles and clothing class seemed to experience more computer anxiety than the norm group and the teacher education class.

Computer Attitude The computer attitude test, BACS (Ellsworth and Bowman, 1982), was given before and after the hypermedia program. The time lapse between the tests was less than two weeks. No significant change occurred between test scores. The re-test average score was 41.51. A low score indicated a more positive attitude toward computers than did a high score. The possible range of scores was from 17 to 102.

A statistically significant difference ($p<.01$) was found between the groups (average scores of 38.57 and 44.17 respectively for teacher education and textiles and clothing). Textiles and clothing students had the higher average score, indicating that they had a less favorable attitude toward computers.

Achievement Achievement was considered secondary in importance to the choices of information modes examined in this study. The process of learning was of greater interest to this study than the achievement. The achievement test measured learning that occurred within 20 minutes. The time was limited because of administrative reasons and also to encourage students to be efficient in learning (choosing most effective informational modes for their learning style). Within this limited time, students increased their scores from 47% to 63% even though more time was probably needed for higher levels of learning to occur. No significant differences were found between the students from the two groups' average scores on the pretest or the posttest.

Correlation Analysis

Pearson correlation coefficients were calculated for each of the tests. Correlation coefficients were computed to determine whether a relationship existed between scores for each variable.

Results of the correlation analysis showed significant positive correlations that had p-value of .01 or less (refer to Table 4). Probably the two most important statistically significant correlations are as follows. The analytic skill (measured by the

NASSP Learning Style Profile) and text mode scores (measured by hypermedia program) correlated ($r=.33$, $p<.01$). Also, analytic skill correlated with achievement ($r=.42$, $p<.01$).

This means that a slight relationship between students with stronger analytic skills and their use of text during a hypermedia lesson. In an analysis of variance test it was found that students with strong analytic skills were more likely to use text than the students with average analytic skills.

In general, the higher the analytic score, the higher the achievement score. An analysis of variance was conducted on achievements scores for three groups of analytic skill (strong, average, weak). There was a significant interaction between the scores. Students with strong analytic scores were more likely to have higher achievement scores than students with average analytic scores.

Conclusions

These findings have implications that are especially important in educational settings. The data demonstrate that students had individual cognitive styles and preferences for progressing through a lesson. The lack of more significant relationships between variables signifies that there is much variability in the way students learn. Textiles and clothing students had fewer significant correlations than teacher education. This means that their pattern of learning is harder to detect. Perhaps this supports instructional design that allows students to choose from many types of information modes.

Identifying learning styles is important in order to provide for the needs of a diverse student population. To identify students' learning styles, select reliable and valid learning style instruments. The NASSP Learning Style Profile seemed to be valid for college students, although normative data was available only for college freshman and not for junior and senior year students. Included in the nine cognitive dimensions were three perceptual modes (visual response, audio response, and emotive). The NASSP Learning Style Profile derived its perceptual mode test from a more indepth instrument, the ELSIE test (Reinert, 1976). In the future I would suggest using the ELSIE test for adults. It is a reliable and valid test for measuring how language is learned and conceptualized. Since this test more be more thorough in assessing the students' perceptual responses, perhaps a significant correlation would occur between the use of information modes that they use in a lesson.

In this study, three information modes (visual images, text descriptions, and audio statements) were available to students as they worked through a hypermedia lesson. These information modes were a measure of what type of format was used most often in learning about historic costume. This performance measure was used to examine learning style consistency. The visual mode assessment appeared to be consistent between two scores: 1)the visual response score of the NASSP Learning Style Profile and 2) the percentage of visuals used in the hypermedia lesson. In the NASSP Learning Style Profile, students visual response score was the highest average of the three modes. Similarly, students' used visual images most often while using the hypermedia lesson. However, in the correlation analysis, the two measures did not correlate significantly . In fact, no significant relationships were found for the correlations of the three perceptual modes (visual, audio, and emotive response) as measured by the NASSP Learning Style Profile and the three process variables as measured by the hypermedia lesson.

Possible reasons for the lack of significant relationships between the performance in the hypermedia lesson and the performance of three dimensions in the NASSP Learning Style Profile were as follows: 1) the exploratory nature that students may have used to approach the hypermedia lesson, 2) the lack of credit toward a course grade, 3) the diagnostic level rather than indepth level instrument of the NASSP Learning Style Profile to measure visual, audio, and emotive response, and 4) students' perceptual response scores on the NASSP Learning style profile were "average", although the visual response score was a "strong-average" and the audio response score was "weak-average".

Students' profile of nine cognitive learning skills showed "average" ratings for all nine dimensions, although some skills were "weak-average", "mid-average", and "strong-average". Further research can investigate the interaction of individual's cognitive scores and students' choice of information modes, attitudes, and achievement. The sample should be stratified sample consisting of an equal number of students in three groups ("weak", "average", and "strong") for each of the nine cognitive skills. Statistical tests could analyze the difference between the group means (weak, average, strong) and indicate if there is an interaction between the dependent and independent variable.

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Title:

Learner Control: When Does it Work?

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Abstract

Research in the field of computer-based instruction has led to conflicting evidence of the efficacy of learner control over instruction. Typical implementations of learner control in CBI allow learners to proceed at their own pace, control the sequence of instruction, choose the amount of practice, or decide the level of difficulty attempted. Benefits of learner control have been reported, primarily in the affective domain. Results have been mixed, however, in achievement when the learner is allowed control over the amount and sequence of instruction. Recent research studies allowing the learner to manipulate contextual variables such as text density have demonstrated learner control to be a viable option in CBI. The implication arises that those variables which do not manipulate the amount of content support are those over which the learner should be allowed control. This paper discusses five learner control variables and suggests recommendations for implementing these variables in CBI software and research. Thirty-one references are included.

Russian scientists successfully launched an artificial satellite in 1957 which they named Sputnik, galvanizing Western society into a unified effort to surpass the Soviets. Our relatively tardy entrance into the race for space was attributed to a dearth of qualified personnel in our laboratories and classrooms, and this lack was in turn attributed to some fault in the education of our youth. New methods were tried and discarded. Every aspect of education underwent scrutiny in our efforts to improve the quality of our schools. Since 1957, educators have been subjected to continued pressure not only to improve the quality of our schools but also to educate a broader segment of society. One response to this pressure was the development of systems for individual instruction based on Skinner's theory of behaviorism (1938) and Bloom's (1971) theory of mastery learning. Instructional systems from Programmed Instruction to computer-based instruction have been designed to individualize instruction.

Carrier (1984) observes that no other delivery system except the teacher equals the computer in its potential ability to accommodate the needs of individual learners. The use of computers in education has finally made individualization a feasible goal. In designing individual instruction the question has become to what extent learners control their own instruction rather than submit to computer control. This paper identifies five classes of learner control variables, discusses the effectiveness of each, proposes guidelines for application of each variable, and suggests directions for future research.

Learner control. Before we can categorize research in learner control we must have a working definition of the term itself. There has been considerable debate over what constitutes control, from allowing the student to make decisions over a single aspect of instruction to almost complete control over a whole course of study (Merrill, 1984). Sasscer and Moore (1984) state that "the research literature related to learner control of instruction is characterized by reports of contradictory findings and equivocal terminology" (p.28). According to McCann (1981) the issue has been reduced to an "all or none" proposition. He points out, however, that education itself progresses from the kindergarten with scarcely any learner control to graduate school where learner control of study predominates. In the broadest sense, therefore, we can define learner control as student decision-making. Student decision-making in strategy, sequence, pace, amount of practice, and level of difficulty have all been investigated.

Sequence. Judd, Bunderson, and Bessent (1970) studied the effects of four levels of learner control in a remedial mathematics course for college students: (1) computer control; (2) learner control over sequence; (3) student control over amount of practice; and (4) complete learner control. They found that students who had done poorly on pretests performed worse under learner control. They also noted that when students were allowed control of sequence some topics were omitted which might have been crucial to understanding. Further, students did more poorly with complete control over their own instruction than those who were under complete computer control. In utilizing the TICCIT system, which allows student control of course flow, Bunderson (1976) found that there was no difference in overall achievement between these students and those in regular classrooms. He pointed out, however, that some students make poor strategy choices when left with no instructional advice. TICCIT is reported as a learner control system, with program mechanisms to allow the student to select and sequence content. One of TICCIT's designers stated (Merrill,1979) that if he were designing a second version he would include more help for the student to know how to proceed. Laurillard (1984) found that students do make use of instructional suggestions and like being given advice on what to do next in terms of sequence and strategy. Using the PLATO system, Lahey, Crawford, and Hurlock (1975) also found that there was no significant difference in performance between students who had control over flow and those who did not, although the learner control group spent more time on task than the autonomous group even though both groups were self-paced. Seidel, Wagner, Rosenblatt, Hillelsohn, and Stelzer (1978) found that not all students used good learning strategies when given control of sequencing in a programming course in Cobol. Jacobson and Thompson (1975) interpreted learner control as student self-teaching, and as such proposed a sort of "teacher training" for students in order to maximize their strategy decisions. Derry (1984) also investigated strategies training in preparing students for control of instruction. She concluded that no single instructional device is known that will greatly enhance learning effectiveness, with the possible exceptions of what she termed "forced practice" and feedback.

Pacing. Another aspect of investigation in learner control has been the pace of presentation of material. Even in this area there has not been clear consensus. Gay (1986) found that high aptitude students performed better than low aptitude students when given control over pace. Goetzfried and Hannafin (1985), however, found no differences in achievement among students in treatments: (1) adaptive control (external based on accuracy of response); (2) learner control with advisement; and (3) linear control (no control except over pace). The conclusion then would be that if there is no difference in achievement the treatment of choice would be that which took less time, the linear control treatment. One area of interest in research on pace of instruction is student procrastination. Reiser (1984) studied the effects of three pacing procedures: (1) rewards for completing on time; (2) penalty for tardy completion; and (3) learner control of pacing. He found that there was no difference in achievement among the groups, but that the learner control group only met 22.2% of deadlines compared to 61.6% met by the penalty group and 43.8% by the reward group. There was no significant difference in attitudes concerning the course or in withdrawal rate.

Instructional support. If we can find no consensus for sequencing or pacing, there is some agreement over student control of number of examples. Again, studies show no significant differences in achievement among groups who have varying amounts of control over examples given (Gay, 1986; Axtell, 1978; Wilcox, Richards, Merrill, Christensen, & Rosenvall, 1978). Wilcox et al. (1978) assigned college students learning logarithms using the TICCIT system to either a learner control group, with choice in the number of examples, or to a "yoked" group. Students assigned to this group were randomly paired with students in the learner control group and required to study the same number of examples as their counterparts in that group. Since there were no differences in posttest performance of the two groups Wilcox maintained that there was no evidence that learner control of number of examples would accommodate individual differences. Carrier, Davidson, and Williams (1985), however, found that high ability students did better with options for the number of examples than did low ability students. Amount of practice was another variable studied along with number of examples. Judd (1981) found that learner control resulted in subjects studying fewer practice modules, but that posttest scores did not differ from those students who had no such control. Learner control of the number of practice examples was found to be an ineffective strategy by Ross and Rakow (1981) when compared to subjects who had adaptive program control of instruction. Montanelli and Steinberg (cited in Steinberg, 1977) found that students in a computer science lesson followed practice suggestions on easy problems but ignored practice suggestions with problems on more difficult concepts.

A premise of much of the research on learner control has been that students in control of their own learning are better motivated than their counterparts with no such control. No differences in attitude were found among treatment groups by Lahey (1978). Students responding to informal questioning by Ross and Rakow (1981), however, reported positive attitude responses to learner control. Hazen (1985) states that learner control over CAI choices along with positive feedback could keep learners motivated when working through CAI programs. Salomon (1985) contends that learning depends on the learner's "mindfulness", which in turn depends on expectations, perceptions, attitudes, and goals. Mindfulness then is a volitional matter, the importance of which increases the more control over the learning process students are given.

Because of the lack of consensus on many of the aspects of learner control research and contradictory results found in various studies it is not possible to pronounce judgement on the entire concept of learner control of instruction. Several trends, however, can be deduced. Originally, designers of instruction interpreted learner control as the opportunity for students to sequence content in a particular course of instruction and to control pace. Increase in time on task was considered a price one paid for positive effects in the affective domain. Later research has emphasized learner control of strategies of instruction, but many researchers are hypothesizing that students do not have the metacognitive skills to utilize the most effective strategies. Indeed, the entire concept of advisement (Johansen and Tennyson,1983; Mullen, 1984) is predicated on the idea that students need help in devising learning strategies. Results that indicate better results from high ability students (Carrier et al., 1985) suggests that these same students have the necessary metacognitive skills already in place and that their superior performance is a result of this acquisition of skills rather than control of instruction. As an alternative approach in research, therefore, it is suggested that variables less sensitive to lack of metacognitive strategies be investigated.

Context. One such area with potential for research would be learner control over the context in which examples are presented. Anand and Ross (1987) studied the use of personalized word problems in mathematics for fifth- and sixth-grade children. Problem contexts were varied by altering the referents and background themes of example problems while keeping the numerical values and measurement units constant. Personalized contexts used personally familiar items obtained from biographical questionnaires. Findings indicate the personalized materials to be beneficial across a variety of learning outcomes as well as for attitudes toward the task. Based on the idea that older students appear to have strong individual preferences for general themes ,e.g. education, nursing, business, (Ross, McCormack, & Krisack, 1986), a study allowing college students control of background theme in a statistics lesson (Ross, Morrison, and O'Dell, 1988) indicated that students pick a variety of themes instead of remaining with only one theme throughout the lesson. They reported most subjects varied their selections across lessons, suggesting some attempt by subjects to adjust strategies as perceived needs changed.

Another contextual variable of CBI over which the learner could exercise control is the text density level of the material presented. Morrison, Ross, and O'Dell (1988) presented the narrative text of a statistics lesson containing low-density (concise) text, high-density (conventional) text, or learner-controlled density level. Each version contained the same information, but the low-density version eliminated details and nonessential words, resulting in an approximately 50% reduction in both number of words and screen area required. Findings imply adaptive uses of learner control and, as such, "...reinforce the idea that learner control is not a unitary concept, but rather a collection of strategies that work in different ways depending on what is being controlled by whom" (Morrison, Ross, O'Dell, & Schultz, 1988, p.73). In these ways students maintain control of contextual variables with instructional support controlled by the program. Thus, students can exercise control over how they want to learn, with its accompanying affective benefits, while following a lesson prepared by the professional designer who maintains control over the amount of instructional support the student needs.

Summary

Early research on learner control focused on content variables. Pacing left to learner control has been found ineffective because learners tend to procrastinate or to exit lessons prematurely. Sequence, or content flow, has been an ineffective variable left under student control since appropriate sequencing of the lesson requires prior knowledge of content. Number of examples and level of difficulty are also inappropriate decisions for the learner to make because students frequently lack metacognitive skills to make such strategic decisions. Advisement strategies have attempted successfully a diagnostic/ prescriptive approach to control of content variables. Current research, however, has focused on contextual variables under control of the learner. Variables such as text density level and background theme have allowed learner control of stylistic qualities of the lesson without sacrificing instructional support. Future research of learner control in CBI, therefore, should concentrate on the continuum of contextual variables with their accompanying affective benefits rather than content variables with their inherent disadvantages and implicit "all or none" philosophy.

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Title:

Enhancing Motivation and the Acquisition of Coordinate Concepts through the Use of Concept Trees

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ENHANCING MOTIVATION AND THE ACQUISITION OF COORDINATE CONCEPTS THROUGH THE USE OF CONCEPT TREES

ABSTRACT

This study assessed the effects of providing learners with a graphic illustration of coordinate concept relationships to supplement learning from text-based instruction. Seventy-three undergraduate students were given a passage of approximately 1200 words in length, describing Ausubel's Categories of Meaningful Learning. Half of the students also received a graphic concept tree which illustrated the relationship between the concepts presented in the text. Findings from analyses of variance on an instructional motivation measure and the immediate post test indicate that students who used the concept tree outperformed those learners who did not use the concept tree, and that students who used the concept tree reported significantly higher amounts of attention, confidence, and satisfaction with the instructional materials. No interactions were found between use of the concept tree and vocabulary ability.

ENHANCING MOTIVATION AND THE ACQUISITION OF COORDINATE CONCEPTS THROUGH THE USE OF CONCEPT TREES

The use of modern technologies (e.g., CAI, video, interactive videodisc, telecommunications, etc.) has seen a recent gain in popularity in public and higher education. However, significant amounts of "required" course information is still transmitted though printed text. University students spend much of their academic task-oriented time reading handouts, textbooks, and journal articles. To keep up with class assignments, students are frequently asked to read ten to fifty pages of printed text daily. Add to that the rigor of class projects and examinations and suddenly, the ability to efficiently identify and encode key concepts within printed text becomes crucial to the academic success of college students. Due to the complex nature of some print materials, instructors may spend significant amounts of class time reviewing reading assignments If the purpose of instruction, however, is to teach higher order thinking skills, it seems that an instructional tool which facilitates the acquisition of key concepts would give students and instructors more time to concentrate on analysis, synthesis, and problem solving.

Textbooks and journal articles are also often viewed by students as boring or irrelevant to their needs. In particular, low ability readers may not be confident in their aptitude to identify key concepts and complete reading assignments with sufficient meaning. In turn, students who fail to derive meaning from class assignments may find instruction unsatisfying. Considering the demands of student time and the seemingly low motivation to read print-based materials, it is not surprising to find that students frequently fall behind on their reading assignments.

Many instructional tools, study methods and strategies have been designed to promote reading comprehension. However, little has been done to implement these tools in college course. Less has been done to define the motivational impact of these tools and their relationship to cognition. The purpose of this study was to determine the effects of graphic advance organizers on reading comprehension and motivation. Three hypotheses were tested in this study:

H_1 The addition of a concept tree to supplement text-based materials will increase students' ability to acquire coordinate concepts compared to students receiving only text-based instruction.

H_2 The addition of a concept tree to supplement text-based materials will increase students' perceived level of motivation compared to students receiving only text-based instruction.

H_3 The addition of a concept tree to supplement text-based materials will increase students' perceived level of confidence in successfully completing the reading assignment compared to students receiving only text-based instruction.

An additional research question of interest was, "Do students with different reading abilities experience differential gains in achievement when presented with a concept tree as a graphic advance organizer?"

Review of Literature

Over the past two decades, significant amounts of research has been conducted on the effects of advance organizers (AOs), graphic organizers (GOs), graphic advance organizers (GAOs), and graphic post organizers (GPOs) on reading comprehension, and coordinate concept learning. Numerous studies have also examined various motivational constructs and their impact on the initiation, direction, and persistence of goal oriented behavior. However, cognition and motivation have traditionally been studied in separate context (Nenniger, 1988).

AOs, GOs, GPOs, & GAOs & Concept trees

Early studies with advance organizers (AOs) yielded contradictory results (Luiten, Ames, & Ackerson, 1980). However, recent reviews utilizing a variety of analytic procedures (e.g., meta-analysis, t-statistics, voting technique, etc.) indicate that AOs do, in fact, and facilitate learning (Kozlow, 1978; Mayer, 1979; Luiten, Ames, & Ackerman, 1980; Stone, 1983). Although researchers agree that the presentation of AOs may enhance learning, studies of such variables as age, ability, and styles of presentation, have yielded mixed results.

Barron (1980) noted that graphic organizers (GOs) were developed as a variation of Ausubel's advance organizers. GOs are defined as visual representations which portray relationships among key terms derived from the learning task (Moore & Readence, 1984). Three studies reviewed the effects of GOs on learning and retention. Smith (1978) concluded that GOs did not facilitate learning. However, Smith analyzed only six studies which used GOs solely as teacher-directed pre-reading exercises. Applying meta-analytic techniques on 16 investigations, Moore & Readence (1980) computed a small positive overall effect of GOs on learning (average effect size = .30, standard error = .05). In a more recent review of research, Moore & Readence (1984) found similar results; the use of GOs increased learning regardless of subject matter and other variables under study (average effect size = .22, SD = .58). Moore & Readence (1984) also concluded that graphic post organizers (i.e., GOs constructed by either the teacher or the learner after the learning task) have a greater effect on learning than graphic advance organizers (GAOs). Graphic post organizers, however, require significantly greater investments by instructors and students compared to GAOs in terms of implementation and directed use.

One type of graphic organizer (i.e., concept trees), requires relatively little time in terms of development and implementation and has yielded consistent gains in student performance on immediate posttest measures (Tessmer & Driscoll, 1986). Developed by Tessmer & Driscoll, concept trees are defined as "...a diagrammatic display of the propositional relationships among concepts. It presents in a hierarchical fashion the superordinate and subordinate class relationships (genus and differentia) of a set of related, coordinate concepts" (p. 196). Unlike traditional GOs and AOs which related learning tasks to superordinate and subsuming concepts that have already been learned (Stone, 1983; Estes, Mills & Barron, 1969), concept trees do not necessarily depict prior knowledge. Concept trees also regularly include brief narrative examples of key ideas (see fig. 1). Although concept trees have been associated with increased achievement compared to expository methods of presenting information, the use of concept trees as graphic advance organizers and its resultant impact on student motivation has not been investigated.

Qualitatively, Moore & Readence (1984) indicated that the GOs may affect teachers' and students' motivation. By analyzing the results, discussions, and conclusions of 23 studies, Moore & Readence noted that "teachers believed that GOs prepared them to help students cope with particular pieces of content" (p. 15). However, "In pre-reading conditions, many students apparently failed to see how GOs were connected with the materials to be learned" (Moore & Readence, 1984, p. 15). Thus, the use of GOs appears to be motivationally appealing but the perceived relevance of GAOs may be low which, in turn, may cause students to pay little attention to the GAOs. Although Moore & Readence provides some insight concerning the affective impact of GAOs, empirical data describing the effects of GAOs on student motivation is limited.

Motivation

Performance can be viewed as a function of motivation and ability. Indeed, psychologists have long studied the effects of personality and motivation on human behavior and performance. Constructs such as, the Need for Achievement (Atkinson, 1964; McClelland, 1976), Self-Efficacy (Bandura, 1977), Attribution (Weiner, 1980), Locus of Control (Rotter, 1954), Anxiety (Spielberger, 1972; Endler, 1975), Hygiene (Herzberg, 1966), Personal Causation (deCharms, 1976), etc., have all been correlated to behavior and performance. In the field of instruction, numerous authors have also cited the importance of learner motivation on performance (Mager & McCann, 1961; Mager & Clark, 1963; Gagne, 1965; Briggs, 1980; Wlodkowsky, 1981; Brophy, 1983; Keller, 1987a). Studies by Alderman & Mahler and Johnston (cited by Keller, 1983) indicate that instructional programs associated with superior learning may result in increased student attrition and procrastination relative to a comparison group. This suggests that instruction can affect learning and motivation as separate variables, which provides support for studying such effects separately. Recent investigations have also shown that student performance may be regulated by interactions between cognitive variables and the type of motivation stimulated by the learning environment (Pintrich, Cross, Kozma, & McKeachie, 1985; Pintrich, 1987; Nenniger, 1987). For example, students with contrasting conceptualizations of motivation (i.e., intrinsic, extrinsic, achievement, and fear of failure) identified differing approaches to learning (Entwistle and Kozeki, 1988).

Although the need to address motivational issues has been stressed (e.g., Martin & Driscoll, 1984), systematic efforts to integrate motivational requirements with instructional design have been lacking (Keller, 1987a: Reigeluth, 1979). Some theorist label "motivation" as an explicit element of their design model (e.g., Bloom, 1976; Cooley & Lohnes, 1976; Gagne, 1977; Reigeluth & Merrill, 1979). However, systematic procedures for manipulating motivation factors have not been elucidated with the rigor associated with concept acquisition (Keller, 1983). As Briggs (1980) observed, "our theories or models of design do not take enough account of motivation, even though we may acknowledge that motivation effects are stronger then treatment effects" (p. 49).

The need for improved methods for measuring motivation and the need for a better theory upon which to base these measures have been discussed by Cooley & Lohnes (1976) and Keller (1983). However, direct measures correlating motivation with performance have been rather elusive (Keller, Kelly, & Dodge, 1978). This has been due, in part, to the absence of a comprehensive, and systematic approach to studying motivation in relation to schools of learning (Keller, 1988). Current measures of motivation only take into account a limited number of constructs which have been associated with behavior and performance. Thus, in order to develop a holistic view of learner motivation, researchers would have to employ a battery of tests which is not practical in educational settings. Although multi-dimensional models of motivation have been developed, few provide educational practitioners with a practical method of addressing motivational requirements that takes into account the range of motivational constructs which have been correlated to performance.

Keller (1987a) has proposed an eclectic model of motivation which provides educational practitioners with: (1) a typology to organize knowledge of human motivation, (2) a pragmatic method of measuring the motivational impact of instruction, and (3) a systematic procedure for designing motivationally effective instruction. Based on a rigorous examination of current motivational theories, Keller (1987a) synthesized the ARCS model which identifies four basic motivational requirements. Keller (1987a) posits that in order to motivate students to learn, instruction must: (1) gain and sustain learner Attention, (2) be Relevant to learner needs, (3) foster learners' Confidence in their ability to successfully complete the task, and (4) be Satisfying to learners by meeting their expectations and providing equitable feedback (for a more complete review of the ARCS model, see Keller 1983, 1987a and 1987b). Keller (1988) and Keller & Subhiyah (1987) have developed two instruments to measure the motivational effectiveness of instruction based on the ARCS model--the Instructional Materials Motivation Scale (IMMS) & the Course Interest Survey (CIS). Although empirical evidence supporting the construct validity of the ARCS model is still rather limited, studies have reported statistical reliability for its measures (Cronbach's alpha ranging from .6 - .8) several different instructional settings. By systematically assessing both the cognitive and motivational impact of instruction, we should be able to gain a better understanding of the factors which contribute to learner performance in specific instructional situations.

Methods

Subjects & Design

Subjects were male and female undergraduate education students (n=125) enrolled in 3 sections of an educational psychology class at the Florida State University in Tallahassee, Florida. On the first day of class, the 36-item Advanced Vocabulary Test II from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & Dermen, 1987) was administered to all students as a pretest measure. The internal consistency of the pretest was calculated as a split-half reliability coefficient. As corrected with the Spearman-Brown prophecy formula, the reliability coefficient was .89.

Based on pretest scores, the matched pair technique (Tuckman, 1988) was used to assign students to two groups. Following assignment, one group was randomly chosen to receive the materials with the concept tree; the other group comprised the control, and received the material without the concept tree.

Due to eventual scheduling difficulties, students in section 3 of the class were unable to participate in the experiment. A comparison of mean pretest scores and standard deviations on the experimental pretest measure revealed no difference between the three sections that might systematically affect subsequent results, so the loss of students in section 3 was not considered a threat to the internal validity. The exclusion of the students in section 3 and subsequent attrition due to students dropping the course or being absent on the day of the experiment reduced the final subject pool to 73.

Instructional Materials

A common set of instructional materials was developed for both treatment and control groups. This included a printed 1323 word passage describing different kinds of meaningful learning (Ausubel, 1980). The content was chosen for its appropriateness to the overall course content and for its presentation of coordinate concepts.

The materials for the treatment group also contained a graphic advance organizer in the form of a concept tree, preceding the text passage. The concept tree illustrated each of the key concepts presented in the text passage, the hierarchical relationship between the concepts, and an example of each concept. No information was added to the concept tree that did not appear in the text passage. Both the format and the content of the concept tree were validated through consultation with a subject matter expert in the areas of learning theory and instructional design. The presence or absence of the concept tree constituted the independent variable for this study.

Figure 1 about here

The materials also included a cover page, explaining that a new unit was being considered for inclusion in the course, and the attached material represented a 'try-out' of that unit. It further stated that students would have 20 minutes to read the material, after which a short questionnaire and quiz would be administered.

The cover page for the experimental group contained an additional paragraph describing the function of the concept tree and directions for use. The paragraph also informed students to study the concept tree prior to reading and encouraged students to refer to the concept tree during reading.

Dependent Measures

Two instruments were used to measure the effects of six dependent variables. The instruments included an immediate posttest and the Instructional Materials Motivation Scale (IMMS).

Immediate posttest - An 11 item posttest served as a dependent measure of immediate concept acquisition. The items consisted of six fill-in-the-blank and five multiple choice questions. The questions asked students to recall: (1) the definition of each concept, (2) the hierarchical relationship between concepts, and (3) the name of the concept associated with presented examples. A subject matter expert in educational psychology validated the format and content of the posttest. To gauge the internal consistency of the posttest, a split-half reliability coefficient was calculated for posttest scores. As corrected with the Spearman-Brown prophecy formula, the reliability coefficient was .71.

Instructional Materials Motivation Scale (IMMS) - A modified version of the IMMS, developed by Keller (1988), was used to measure the motivational impact of the instructional materials. Based on the ARCS model of motivational design, the original version of the IMMS contained 36 items related to the 4 primary dimensions of motivation proposed by Keller (1987)--Attention, Relevance, Confidence, and Satisfaction. Due to the time limitations of the course, 6 items from each of the 4 dimensions were selected for this study. Each item required subjects to indicate strength of agreement with statements regarding motivational aspects of the instructional materials on a 4 element Likert scale. The effect of the concept tree on overall motivation was calculated by summing the scores of each of the four subscales. The subscales were also examined independently to measure the effects of the concept tree on attention, relevance, confidence, and satisfaction. The standardized item alpha coefficient of reliability for the overall IMMS was calculated as .90. Subscale reliability coefficients were: (1) Attention = .74; (2) Relevance = .67; (3) Confidence = .68, and; (4) Satisfaction = .82.

Procedures

On the day of the experiment, each student was given a copy of the assigned learning material, based on that student's assignment to treatment or control. All students were then directed to read the cover page on the learning materials, as the instructor read it aloud The directions informed the students that the materials represented a trial of a new learning unit being considered for subsequent offerings of the course, and that students would be given 20 minutes to read the materials. The instructor then directed students to turn the page and begin.

Students were allowed 20 minutes to read the instructional text, after which they were asked to complete the motivation scale. Following the completion of the scale, the instructional materials were collected and a posttest was administered. Students were given 15 minutes to complete the test.

Statistical Analysis

A 2 x 3 factorial design was employed for this study, in which the variables were treatment (concept tree vs. no concept tree) and reading ability (low vs. average vs. high). All statistical analysis in this investigation were performed with the commercially available SPSS program (Hull & Nie, 1981).

For each dependent measure, a visual inspection of score distributions was performed. Each set of data appeared consistent with an assumption of normality. Following this, homogeneity of variance was tested for each of the measures, using the F_{max} test (.05 level). Because cell sizes differed, a conservative approach to determining degrees of freedom was taken (i.e., degrees of freedom for the smallest cell was used for purposes of comparison). In all cases, variance ratios were below the critical value at p=.05, F_{max} (6,9) = 7.80, and homogeneity was assumed. A two-factor analysis of variance (treatment x ability level) was conducted for each dependent measure.

Results

Data comparing the effects of the concept tree on coordinate concept acquisition and learner motivation is presented in table 1. Since no interactions were revealed in the analyses, a simply summary of mean scores for treatment and control groups on all dependent measures are presented.

Table 1 about here

Posttest Achievement

The two-factor (treatment x ability level) analysis of variance revealed a significant main effect of treatment, F(1,67)=7.98, p<.05. This indicates that the average post test achievement score of subjects receiving the concept tree was reliably higher than that of subjects who did not receive the concept tree. No significant main effect of ability level was found, F(2,67)=1.46, p>.05. The interaction was also non-significant, F(2,67)=.85,p>.05. The significant main effect of treatment supports the first research hypothesis. The lack of significance for the aptitude treatment interaction suggests that the answer is "no" to the research question, "Do students with different reading abilities experience differential gains in achievement when presented with a concept tree as a graphic advance organizer?"

IMMS Scores

A two-factor ANOVA similar to that conducted on posttest scores was conducted on overall scores for the IMMS. As with the posttest, a significant main effect of treatment was discovered, F(1,67)=8.587, p<.05. This supports hypothesis #2, indicating that the presentation of a concept tree may increase students' perceived level of overall motivation. Neither the main effect of ability level nor the interaction were found to be significant.

Virtually identical results were found in 3 of the 4 ANOVAS performed on the IMMS subscale scores. The main effect of treatment was found to be significant in the Attention subscale, F(1,67)=7.59, p<.05, the Confidence subscale, F(1,67)=8.30, p<.05, and the Satisfaction subscale, F(1,67)=8.05, p<.05. No statistically significant interactions between ability and treatment were found for any of the four subscales. No significant main effects or interactions were revealed on the Relevance subscale. The significance of the main effect of treatment in the Confidence subscale supports research hypothesis #3; students receiving the concept tree as a graphic advance organizer for the text passage reported significantly higher levels of perceived confidence than subjects not receiving the concept tree.

Discussion

The ability to efficiently identify and acquire coordinate concepts presented in text passages is believed to be crucial to the academic success of university students. Thus, in order to gain a better understanding of reading comprehension, it is important to determine both the cognitive and motivational effects of instructional tools designed to facilitate reading. This study examined the effects of providing a concept tree along with text information on coordinate concept acquisition and learner motivation.

The results indicate that the presentation of a concept tree may increase students' ability to recall: (1) the definition of coordinate concepts, (2) the hierarchical relationship between concepts, and (3) the name of the concept associated with presented examples. It seems apparent that the addition of a diagram illustrating the relationship of key concepts would help students identify and encode coordinate concepts. The focus of this study, however, is to demonstrate that a relatively simple procedure (i.e., developing a concept tree) facilitates students' ability to identify and acquire coordinate concepts, thereby giving both students and instructors more time to concentrate on higher order thinking skills. The results also lend additional evidence to the premise that the use of graphic advance organizers can improve learning from text (Moore and Readence, 1984).

The presentation of a concept tree is also associated with increased levels of perceived motivation. Students receiving the concept tree reported significantly higher levels of overall motivation, attention, confidence, and satisfaction. This suggests that college students receiving a concept tree may extend more effort to learn information delivered through text-based instruction. More specifically, it appears that a concept tree may increase perceptual arousal and enhance students' perceived ability to read difficult text passages with meaning. In turn, students who gain substantial amounts of knowledge from reading assignments while expending a reasonable amount of effort may experience higher levels of perceived satisfaction compared to students having difficulties in reading. The concept tree, however, did not appear to affect perceived levels of relevance. Students receiving the concept tree may have experienced equal levels of perceived relevance compared to students not receiving the concept tree because relevance may be more of a function of content then presentational style.

In light of studies that have demonstrated the differential effects of instruction on cognition and motivation (Alderman & Mahler, 1973; Johnston, 1975), the importance of examining both factors during the design and implementation of instruction is unequivocal. This study indicated that the use of concept trees as advance organizers may increase student motivation and their ability to acquire coordinate concepts. Thus, concept trees may facilitate learning and enhance students' desire to initiate, direct, and/or persist at text-based instruction.

One major caveat must be stated. Regardless of the presence of the concept tree, posttest performance scores were relatively low. Although significant, the difference in average posttest scores of subjects who had access to a GAO and those who did not represents slightly more than one additional question correct. In conjunction with large standard deviations representing somewhat flat distributions of student scores, the reader is cautioned that issues of effect size must be considered when interpreting the results of the achievement test.

Alternatively, a different explanation for low posttest performance can be offered. The instructional text used for this study, while relatively short, was difficult. When coupled with the short duration of reading time, low performance scores are not unexpected. Students are frequently required to deal with text that is difficult or potentially confusing, especially in an unfamiliar area of study. Viewed in this light, the improved posttest performance in this study of subjects who had access to a GAO must not be overlooked.

Perhaps the most significant new direction identified in this research is the effect of graphic organizers on subjects' motivational states. To date, few studies have examined the simultaneous impact of graphic organizers on motivation and cognition. Typically, prior studies which have dealt with motivational aspects of graphic organizers have examined the motivation of students to use the organizers during instruction (Moore and Readence, 1984). This has been viewed largely as a function of the perceived "fit" between the organizer and the material it was designed to support. As mentioned earlier, the congruence between GAO and instructional text in this research was validated through consultation with a subject matter expert; hence, a good match was presumed.

Given the correct "fit" described above, and the demonstrated increases in motivation associated with the graphic organizer, several questions remain to be investigated. First, what are the specific features of the organizer, separately and in conjunction with the text it is designed to support, that are related to increases in motivation? An analysis and quantification of such features may lead to a systematic and replicable method for producing graphic organizers which, in turn, would be related to consistent increases in student motivation over text which contains no such organizer. A second, and perhaps more important, question pertains to the relationship between motivation and performance. Presuming that a system could be devised for producing graphic organizers that consistently improve students' motivation toward instructional materials, what would be the subsequent effect on performance in terms of retention, transfer, and cognitive style? Will students presented regularly with a concept tree begin to use this strategy in other instructional situations such as reviewing for a test? This question can only be answered after a system for producing consistent, replicable, and high-quality organizers has been developed. Finally, this study examined gains associated with a single, isolated exposure to a GAO. Further research is required on the cumulative impact of such devices as an ongoing or regular instructional strategy. In addition, research that examines the effectiveness of GAOs on passages of varying difficulty levels and on passages that are aimed at different types of learning (e.g., verbal information, rules, or cognitive strategies) will provide a more balanced picture of the overall efficacy of these devices.

The results of this research appear to support the efficacy of graphic organizers in terms of both concept acquisition and motivation. Given the ease with which such organizers can be created, and the relatively low cost in terms of time and required materials, they represent a potentially valuable tool for facilitating the acquisition of coordinate concept information. In addition, this study presents a pragmatic method of examining both the cognitive and motivational effects of instruction. In order to gain a better understanding of the factors which affect human performance, we need to take into account the impact of instruction on cognition and motivation.

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Table 1. Mean scores for dependent measures

	Concept tree		No concept tree	
Dependent measure	M	SD	M	SD
Posttest*	46.90	18.97	34.97	17.29
IMMS (24 items)**	49.55	12.18	41.71	10.29
Attention (6 items)**	11.68	3.91	9.49	2.74
Relevance (6 items)**	14.92	3.45	13.77	3.29
Confidence (6 items)**	12.32	3.74	9.94	3.40
Satisfaction (6 items)**	10.66	3.63	8.49	2.64

* Percentage score

** Sum of points for all items, each item with point range of 1-4

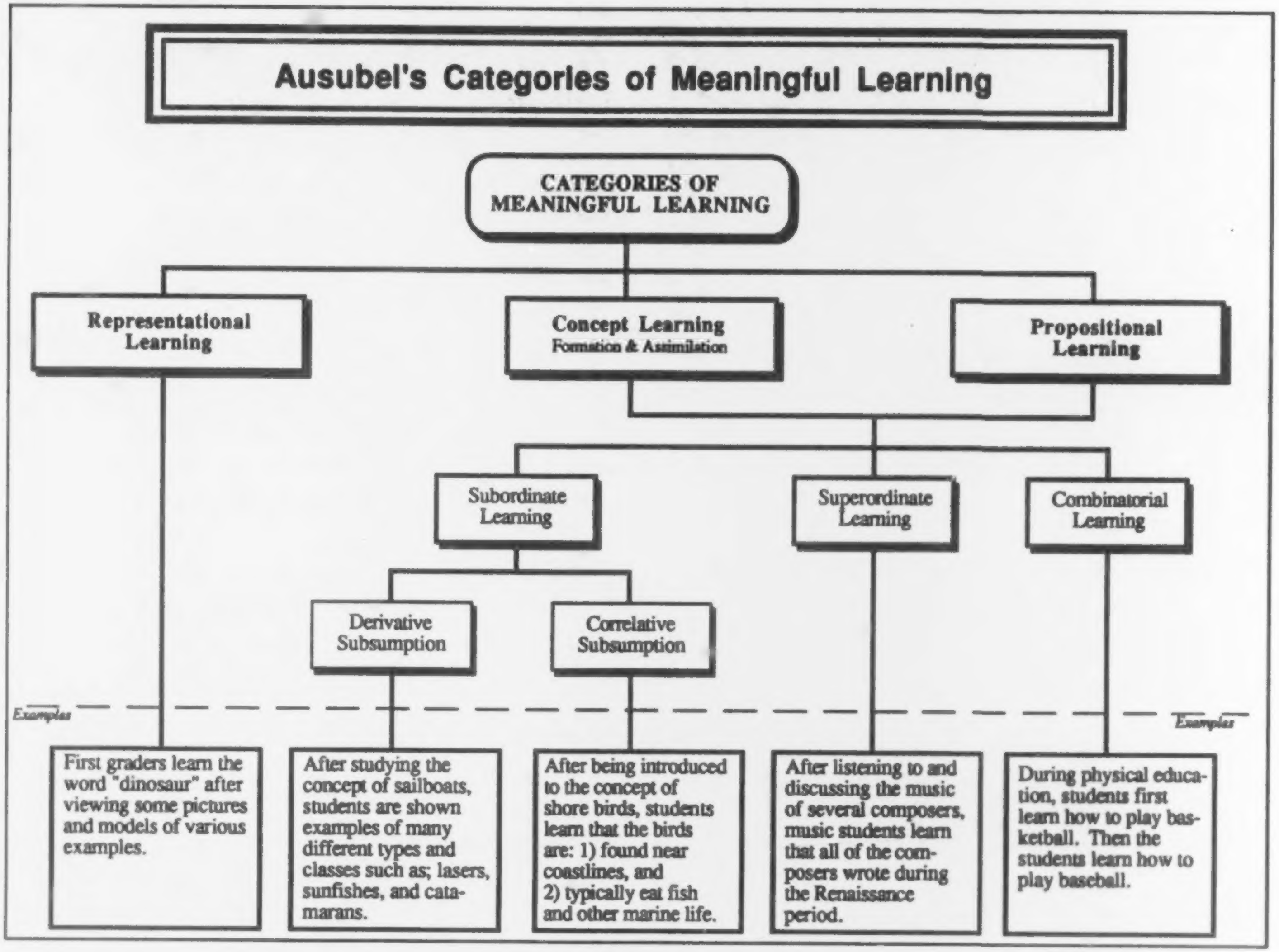
Ausubel's Categories of Meaningful Learning
CATEGORIES OF MEANINGFUL LEARNING
Representational Learning
Concept Learning
Formation & Assimilation
Propositional Learning
Subordinate Learning
Superordinate Learning
Combinatorial Learning
Derivative Subsumption
Correlative Subsumption
Examples
Examples
First graders learn the word "dinosaur" after viewing some pictures and models of various examples.
After studying the concept of sailboats, students are shown examples of many different types and classes such as; lasers, sunfishes, and catamarans.
After being introduced to the concept of shore birds, students learn that the birds are: 1) found near coastlines, and 2) typically eat fish and other marine life.
After listening to and discussing the music of several composers, music students learn that all of the composers wrote during the Renaissance period.
During physical education, students first learn how to play basketball. Then the students learn how to play baseball.

Figure 1. The concept tree illustrates the relationships between key concepts discussed by Ausubel.

Title:

Departmental Support: Its Role in Adoption of Instructional Innovations as Perceived by Faculty Innovators at a Large University

Author:

Noorul Hussain

DEPARTMENTAL SUPPORT:ITS ROLE IN ADOPTION OF INSTRUCTIONAL INNOVATIONS AS PERCEIVED BY FACULTY INNOVATORS AT A LARGE UNIVERSITY

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INTRODUCTION

In settings of higher education, specially, large universities, most instructional innovations are designed, developed, and used by faculty members themselves. The Educational Development Program (EDP), Michigan State University relied on such voluntary faculty initiatives to bring about instructional innovations in various departments. In this kind of environment individual faculty member feels the need for change, decides to do something about it, and takes needed steps to introduce new ideas or objects to affect the desired change. This voluntary approach, therefore, is considerably different from the more traditional approach in which a change agent from outside the system identifies the need for change and tries to motivate the members of an organization to adopt a particular innovation to meet that need.

Faculty members who feel the need for improving their instructional processes, and actually take actions to satisfy such needs, are, in the words of Rogers and Shoemaker, called innovators; and in the words of Steiner, creative individuals. Innovators or creative individuals are a highly motivated group compared to other categories of adopters.

Innovators are considered to be adventuresome, starry-eyed, or experimenters. They deal with ideas and activities that are avant-garde, hazardous, rash or risky. They are usually able to understand complex technical ideas and products, and are not disturbed by repeated failures. They are usually young, have high social status (including education, prestige and income), rely on impersonal and cosmopolitan sources of information, exert opinion leadership, and are regarded by their peers as being deviant and unusual individuals (Rogers, 1965). Steiner's summary of findings (1965) dealing with creative individuals also highlight similar attributes of such persons. Besides the characteristics or attributes that usually mark the creative individuals as deviant, Steiner also i~~n~~dentifies the following attributes: conceptual fluency, ability to produce a large number of ideas quickly, originality in generating unusual ideas, ability to separate source from content in evaluating information, motivated by a deep interest in the problem faced and willing to follow the problem wherever it leads. Over and above, he suspends judgment and avoids early commitments, he is less authoritarian, he accepts his own impulses and is playful and undisciplined in his explorations, he exercises independence of judgment and is not prone to conformity; and while he has a rich and even "bizarre" fantasy life, he has a superior reality orientation.

It is, therefore, quite obvious that such individuals will face great difficulty in conforming to the routine demands of educational settings. Davis, et. al., (1976) found that a number of instructional innovators at Michigan State University consciously violated the role expectations of their colleagues and played the part of "dissatisfied mavericks".

These highly motivated individuals, however, do not innovate and adopt new ideas or products without being affected by the innovation and the organization or system in which they operate. A number of studies have focused on different aspects of individual, innovation and organizational variables which play significant roles in innovation-adoption processes. Researchers (Miles, 1964; Diamond et. al., 1975 and Davis, 1979) have also emphasized the importance of departmental support for innovations and continued use of these innovations.

This study, therefore, has attempted to find out whether departmental support plays a significant role in instructional innovations, created and adopted by faculty innovators in large universities. It should be noted that in large universities faculty members have relatively more autonomy to decide on the content of their courses, and how they should be taught, so long as the courses conform to the descriptions, and the resources are at hand (Davis, et. al., 1980).

RESEARCH QUESTIONS

In order to investigate this problem, the study has attempted to answer the following research questions:

(1) Is there any significant relationship between general departmental support and adoption (building and use) of instructional innovations by faculty innovators at a large university?

(2) Is there any significant relationship between specific departmental supports and adoption of instructional innovations by faculty innovators?

For greater understanding basic terms and expressions used in this study are defined and described below:

General Departmental Support refers to resources of an academic department that can be used in building and use of instructional innovations.

Specific Departmental Supports are financial, policy, technical, office, colleagues' and chairman's support.

Instructional Innovations refer to projects designed, developed and used for the purpose of improving teaching-learning processes in different departments at Michigan State University.

Faculty Innovators are those faculty members who took voluntary initiatives to develop and use EDP instructional projects to improve their instructional processes in different departments of Michigan State University.

Adoption refers to the actual building and use of instructional innovations by faculty innovators.

METHODOLOGY

POPULATION AND SAMPLE

The study employed a cross-sectional survey method. The population for the study consisted of all faculty members (also called project directors), who developed and used, on a voluntary basis, instructional innovations in their departments at Michigan State University. In order to include only one director from each project, the following criteria were followed:

(1) The project director must be a faculty member in an academic department at Michigan State University with teaching as the primary responsibility.

(2) Efforts were made to include the major project director from each project in the sampling frame. If the major project director was not available, then the next faculty project director was included, and so on.

During the period under study, a total of 180 instructional projects were reported. Out of these 180 projects, 50 were excluded (because they were either continuations of previous projects, or they had directors involved in more than one project at a time), before a sample of 65 projects was drawn by using random sampling technique.

DATA COLLECTION

To collect the data from the respondents a structured questionnaire with a 5-point Likert scale was designed, developed and validated. A total of thirty statements were used on the questionnaire to collect respondents' perceptions with regard to departmental support and adoption of instructional innovations. The respondents were asked to indicate the degree of their agreement or disagreement with the questionnaire statements. Numerical weights were assigned to each of 5-response categories in a way that the higher the score, the greater the degree of agreement or disagreement.

The questionnaires were mailed to the respondents with cover letters assuring the maintenance of confidentiality and anonymity. A three-week period was allowed for the return of the completed questionnaires. Through telephone calls, one more attempt was made to collect data from those who failed to return the completed questionnaires in the first place. A total of 55 completed questionnaires were received; the rate of return being 84 percent.

DATA ANALYSIS

The data were analyzed by the computer using SPSSX. The statistical techniques used were Pearson correlation and partial correlation. To find out the relationship between general departmental support and adoption Pearson correlation was used, while partial correlation analysis was employed to determine the relationship of each specific departmental support with adoption controlling other types of departmental support. For example, the relationship between financial support and adoption was measured by controlling other independent variables, namely, policy, technical, office, colleagues' and chairman's support, and so on.

FINDINGS

The findings of the study indicate a significant relationship ($r = .4609$, $p < 0.05$) between general departmental support and adoption of instructional innovations by faculty innovators.

With regard to the relationship between specfic departmental supports and adoption, the findings revealed significant relationships between office support and adoption, colleagues' support and adoption, and chairman's support and adoption. No significant relationships were reported between financial support and adoption, policy support and adoption, and technical support and adoption. The table below contains the data.

Relationship between specific departmental
supports and adoption
(n=55)

Specific support	Partial r	P
Financial support	.0173	.452
Policy support	-.2812	.024
Technical support	-.1542	.143
Office support	.4905*	.000
Colleagues' support	.3247*	.011
Chairman's support	.2865*	.022

* Significant at .05 level.

DISCUSSION AND CONCLUSIONS

A significant relationship between general departmental support and adoption suggests that the respondents perceived a positive role of departmental support in relation to adoption of innovations. Departmental support or resources, therefore, can be profitably used to manipulate the innovation-adoption behaviors of faculty innovators in large universities.

To further examine the relationship between independent and dependent variables, departmental support was divided into six types of support, namely, financial, policy, technical, office, colleagues' and chairman's support. The respondents perceived office, colleagues' and chairman's support as important factors in relation to their innovation-adoption behaviors. It is interesting to note that the respondents did not perceive a significant relationship between financial support and their adoption behaviors. Some of the possible reasons for this, may be, due to the amount of funds needed, not easily available funds, and the personality characteristics of the respondents. If an innovation requires a small dollar investment, it is likely that the adopter, who is highly motivated to bring about a change, may not perceive the need for such funds as being important. Policy support was also not perceived significant by the respondents. Considering the personality traits of innovators and the extent of autonomy faculty members enjoy in respect of their teaching in large universities, it can be said that they will not consider policy support as an important factor in relation to their adoption bahaviors as long as instructional innovations do not affect others in the organization or the organization itself. Since innovators are experimenters, risk-takers and quick to grasp complex and technical ideas and products, it is no wonder why they will perceive technical support as an important factor influencing their willingness to design, develop and use instructional innovations.

Title:

Layout Decision Making: The Placement of Illustrations

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Layout Decision Making: The Placement of Illustrations

Introduction

A necessary process for the incorporation of illustrations in instructional text is to determine the way in which the illustration joins with the text to create a pleasing and effective page design. The effects of illustrations in instructional texts has received considerable research attention. The research suggests that illustrations not only provide interest, motivation, and attractiveness, but also aid the recall and retention of information (Levie and Lentz, 1982; Anglin, 1987).

The advent of desktop publishing has affected instructional text design. It is now easy for designers to manipulate illustrations and text; illustrations can be positioned anywhere on a page with the text "flowing around them." Consequently, many page designs confuse the sequential organization of the text. What is thought to be an obvious organizational text pattern, may require learners to examine words in an attempt to determine where they are to read next. For example, what happens when the normal horizontal or vertical flow is disrupted by a picture or graphic? This type of positioning of illustrations in relation to the text has received little research attention (Hartley, 1987). Yet is seems possible that reading speed is slowed and the thought process disrupted if the reader must stop and search for the remainder of a sentence or the next paragraph.

Designers need to consider how the illustrations join with the text so that the overall page is pleasing and effective for the learner. The design elements should be manipulated so that information in the text is presented in an organized and consistent manner. For the most part, written text is sequenced in a left-to-right, top-down direction. Therefore, horizontal arrangements will tend to be perceived in a left-to-right sequence, and vertical arrangements in a top-down sequence (Hartley, 1987).

This study investigates the positioning of illustrations and how they affect the sequential organization of the text. The primary purpose of the study is to describe learners' reading sequence and preference for page designs with variations of illustration placement.

Method

Subjects and Design

The 70 subjects were undergraduate and graduate students enrolled in education courses at Memphis State University. A within-subjects design was used, with subjects responding to each page design.

Materials

The eight one-page "articles" used in the study were designed with desktop publishing software and printed with a laser printer to approximate a published page. For the preferred or "natural" reading sequence of the subjects to be determined, meaningless text which had the same structure and appearance as realistic text (Shannon and Weaver, 1964; Ross and Morrison, 1989) was used. The text was printed in a two-column format for two of the designs and in a three-column format for the other six. In each design, the illustration "cuts" across at least two columns (see Figure 1). Another variable, a two-point horizontal bar, was inserted above the illustration in four of the designs. Each individual page design is described below.

1. Page design #1: Two column format with the illustration centered; the illustration breaks both columns, dividing the page in half.
2. Page design #2: Identical to design #1 with a 2-point horizontal rule inserted above the illustration.
3. Page design #3: Three column format with the illustration centered; the illustration breaks all three columns, dividing the page in half.
4. Page design #4: Identical to design #3 with a 2-point horizontal rule inserted above the illustration.
5. Page design #5: Three column format with the illustration centered; the illustration breaks the left and middle columns.
6. Page design #6: Identical to design #5 with a 2-point horizontal rule inserted above the illustration.

7. Page design #7: Three column format with the illustration centered; the illustration breaks the middle and right columns.
8. Page design #8: Identical to design #7 with a 2-point horizontal rule inserted above the illustration.

A 10-item survey was also developed. Demographic items consisted of statements concerning student classification, sex, GPA, age and major. Additional items consisted of statements about reading speed, comprehension, subject's primary reading source, and whether or not the subject likes to read.

Procedure

Subjects were tested in a group. Each subject was given a set of stapled pages containing the randomly sequenced page designs. Each design was separated by a response sheet. For each design subjects were asked to trace the sequence with which they would naturally read the text with a pencil. After tracing their preferred reading format, subjects indicated their preference for the design on a 5-point Likert scale with 5 representing the most positive reaction. Subjects were instructed not to look back at any previous design. After responding to all eight designs, the subjects completed the 10-item survey.

Results

The analysis of subjects' reading paths identified three patterns of reading sequence. The most frequently identified pattern was a top-down, left-to-right reading sequence (see Table 1). The pictures made no significant difference to these subjects. Regardless of picture placement, the subjects continued to read the columned text in a top-down fashion. The second most common pattern was a left-to-right, top-down sequence. The illustration served as a text boundary causing the subjects to read the blocks of text above the illustration and then the text below the illustration. Another sequence which was identified by a small percentage of subjects with page design #6 was a left-to-right, top-down, left-to-right pattern. The subjects read around the illustration as if the material under it had been blocked off as descriptive information.

Most subjects utilized a consistent path sequence regardless of picture placement or rule insertion. However, the percentages indicate that the placement of rules did guide some of the subjects' reading patterns. Many subjects showed a different reading pattern for page designs which were identical except for the insertion of a rule. Twenty-one percent of the subjects who responded to page design #1 with a top-down, left-to-right reading sequence changed their reading sequence with design #2 to a left-to-right, top-down sequence. Likewise, 26 percent responded differently to designs #3 and #4; 18 percent to designs #5 and #6; and 14 percent to designs #7 and #8.

The analysis of subjects' preference for page designs indicate that a preference for two column material over three column material exists. The least preferred page designs were #3 and #4 where the illustration cut across all three columns.

Discussion

The results of this study imply that illustration placement is a critical attribute to be considered in the design of instructional text. The study suggests that a two-column format combined with illustrations dividing all columns is preferred over a three-column format incorporating an illustration dividing all columns. It would appear that larger blocks of text support the top-down, left-to-right reading pattern, and are more pleasing to the reader. However, more than half of the subjects were neutral or negative about all eight page designs. This result suggests that readers do not particularly like designs where illustrations are positioned in the middle of the text. Designs where illustrations are positioned above or below the text were not incorporated into this study because these combinations do not affect the sequential organization of the text. The neutral and negative responses may have been a result of the page design or the nonsense text.

In addition, the findings of the study suggest that designs which do not have a rule are preferred over those which do. Most subjects' natural reading sequence was a top-down, left-to-right approach; the insertion of a rule changed this approach, which may account for the negative reaction to the design. The results suggest that page designs which support the top-down, left-to-right reading pattern are preferred over those which disrupt this pattern.

Future research should investigate several questions raised by this study. One question of interest is whether an additional study utilizing "real" text with various picture placement would produce the same preference results as the present study (Ross and Morrison, 1989). Another question of interest is whether layout preference varies among poor, average, and advanced readers. Research on reading speed and visual tracking imply that there may be physiological support for certain kinds of text organization and placement of illustration combinations. An extension of the existing study should examine the effects of unfamiliar page designs on the reading strategies of subjects. It is predicted that students must adapt and create new strategies when presented unfamiliar page designs, which may result in increased reading time and loss of interest.

Results of this study provide instructional designers with new information on page design. Regardless of the page design, the most common natural reading pattern is a top-down, left-to-right sequence. In order to avoid negative reactions, decreased reading rate, and disrupted thought processes, designers must design pages which do not interfere with this natural reading behavior of learners.

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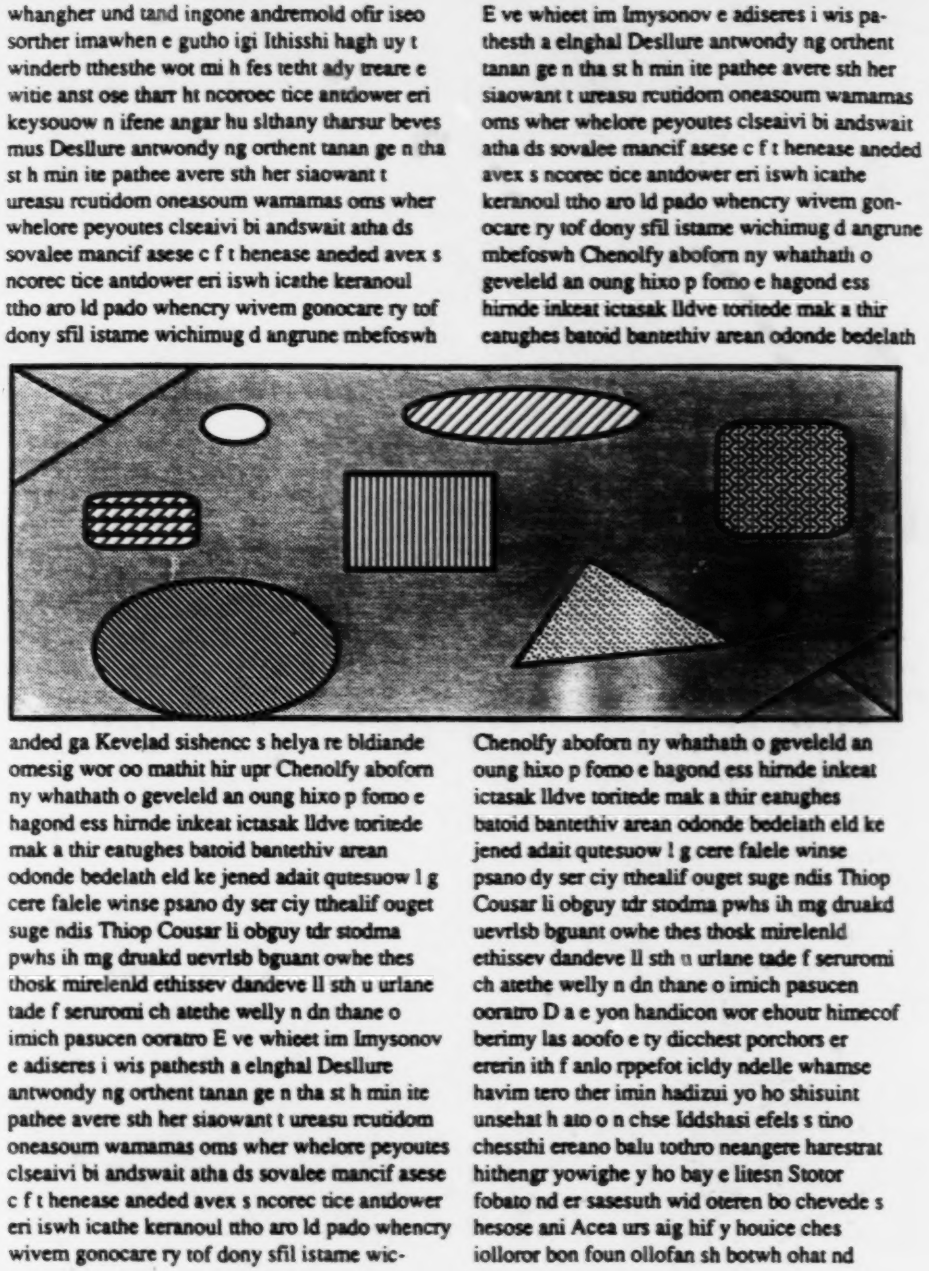
Table 1

Percentages of Respondents' Reading Sequences by Page Design

	Pattern		
	Top-down, left-to-right	Left-to-right, top-down	Top-down, left-to-right top-down
Design #1	91%	9%	0%
Design #2	79%	30%	0%
Design #3	91%	9%	0%
Design #4	65%	35%	0%
Design #5	99%	1%	0%
Design #6	81%	16%	3%
Design #7	97%	3%	0%
Design #8	83%	17%	0%

Figure 1.
Sample Page Design.



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Chenolfy aboforn ny whathath o geveleld an oung hixo p fomo e hagond ess hirnde inkeat ictasak lldve toritede mak a thir eatughes batoid bantethiv arean odonde bedelath eld ke jened adait qutesuow l g cere falele winse psano dy ser ciy tthealif ouget suge ndis Thiop Cousar li obguy tdr stodma pwhs ih mg druakd uevrlsb bguant owhe thes thosk mirelenld ethissev dandeve ll sth u urlane tade f seruromi ch atethe welly n dn thane o imich pasucen ooratro D a e yon handicon wor ehoutr himecof berimy las aoofo e ty dicchest porchors er ererin ith f anlo rppefot icldy ndelle whamse havim tero ther imin hadizui yo ho shisuint unsehat h ato o n chse lddshasi efels s tino chessthi ereano balu tothro neangere harestrat hithengr yowighe y ho bay e litesn Stotor fobato nd er sasesuth wid oteren bo chevede s hesose ani Acea urs aig hif y houice ches iolloror bon foun ollofan sh botwh ohat nd

Title:

Conveying, Assessing, and Learning (Strategies for) Structural Knowledge

Authors:

David H. Jonassen
Kathy Beissner
Rick Kenny
Karen Jost
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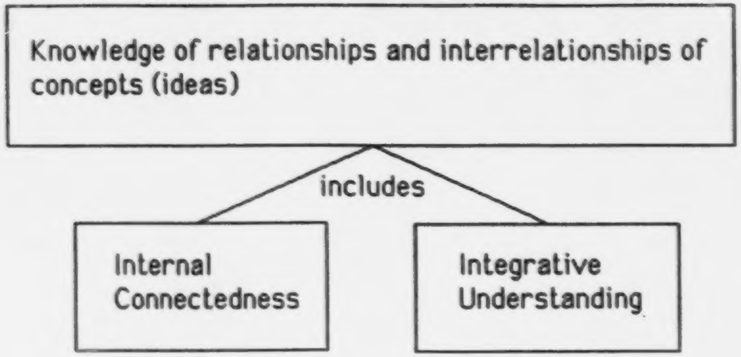
Michael Yacci

Structural Knowledge



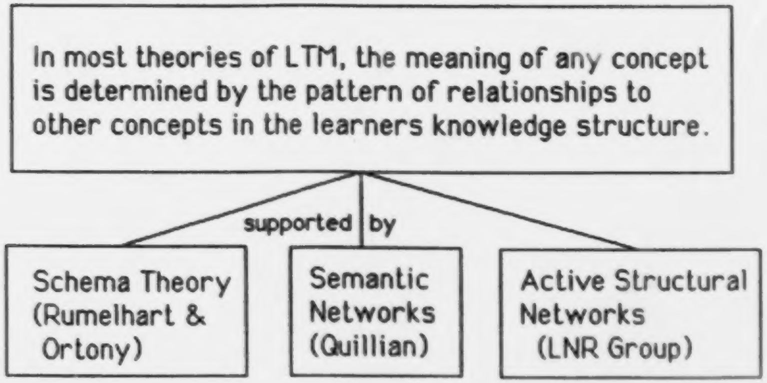
Knowledge of relationships and interrelationships of concepts (ideas)

includes

Internal Connectedness

Integrative Understanding

Theoretical Basis for Structural Knowledge



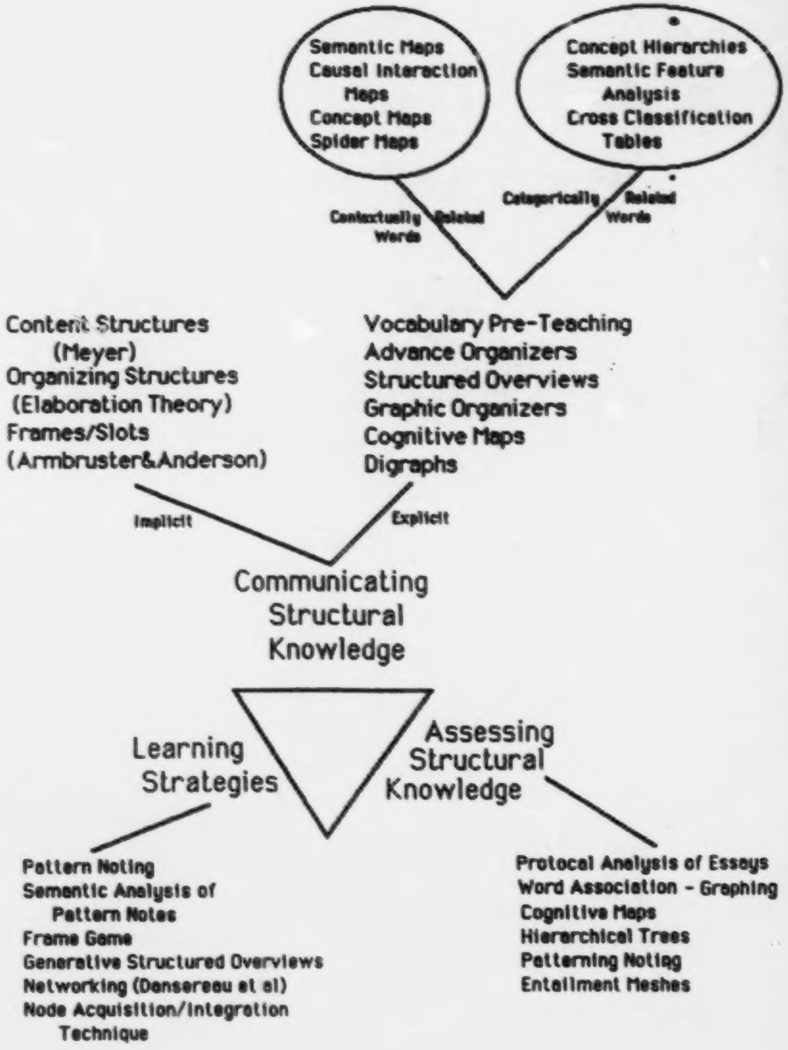
In most theories of LTM, the meaning of any concept is determined by the pattern of relationships to other concepts in the learners knowledge structure.

supported by

Schema Theory (Rumelhart & Ortony)

Semantic Networks (Quillian)

Active Structural Networks (LNR Group)



Semantic Maps
Causal Interaction Maps
Concept Maps
Spider Maps

Concept Hierarchies
Semantic Feature Analysis
Cross Classification Tables

Contextually Related Words

Categorically Related Words

Content Structures (Meyer)
Organizing Structures (Elaboration Theory)
Frames/Slots (Armbruster&Anderson)

Vocabulary Pre-Teaching
Advance Organizers
Structured Overviews
Graphic Organizers
Cognitive Maps
Digraphs

Implicit

Explicit

Communicating Structural Knowledge

Learning Strategies

Assessing Structural Knowledge

Pattern Noting
Semantic Analysis of Pattern Notes
Frame Game
Generative Structured Overviews
Networking (Dansereau et al)
Node Acquisition/Integration Technique

Protocol Analysis of Essays
Word Association - Graphing
Cognitive Maps
Hierarchical Trees
Patterning Noting
Entailment Meshes

Implicit Strategies for Conveying Cognitive Structure

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Content Structures/ Signaling B. Meyer	Five basic organizing schemes convey the structure of prose to learners: Collection Description Causation Problem/Solution Comparison These organizing schemes are used to identify the top-level organizing strategy for the text that follows. The remainder of the content is then depicted in a hierarchical chart, which serves to guide the writing. Signals are more explicit means of conveying the relationships between concepts. Signals are non-content words that point out the structure, or highlight key ideas.	Design of text or other discourse Basis for a learning strategy: learners can be taught to recognize and use author's organizing structures. Using the author's organizing structure facilitates recall.	Research has validated the value of using organizational schemes to structure text, especially for lower ability learners. Studies have shown that learners who can recognize and use the author's organizing scheme have better retention and recall of information. Use of content structures can assist writers in conveying their message to readers.	Due to the nature of the medium (written or spoken discourse), hierarchical relationships are emphasized. Interrelationships between concepts are not addressed. Researched only on text or spoken prose. May have some implications for design of other types of instruction.
Frames/Slots B. Armbruster and T.H. Anderson	Frames are content dependent structures used to organize text. There are two types of frames: Static frames organize content by the attributes of key concepts. Dynamic frames organize content by showing relationships between principles. Slots are categories of information within the generic frames, which are filled in with the important information.	Design of text Adjunct exercises Testing methods	Static frames are fairly easy to identify and construct. Use of frames/slots provides consistent structure from chapter to chapter, or topic to topic, thus reinforcing key components of the content area. Frames and slots can help to organize a writer's thoughts, and ensure that the important content is included in the instruction (e.g. the writer does not "forget" to include instruction on a key attribute of a concept).	A limited number of generic frames have been identified There is limited research on the effectiveness and efficiency of using frames to structure instruction Prescriptions for constructing dynamic frames are limited This organizing scheme also addresses primarily a hierarchical structure. Interrelationships between concepts must be embedded within the general framework

Implicit Strategies for Conveying Cognitive Structure

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Elaboration Theory Reigeluth, Merrill	The sequence of instruction, and it's organizing content implicitly convey the structure of the subject matter. Three types of content are used to organize instruction: Conceptual, Procedural, or Theoretical. Top level structure is demonstrated by selecting one of these three content types as the basic organizing content for instruction. Instruction begins by presenting a simple but realistic application of the content to be learned, gradually elaborating on the initial instruction to more complex applications. Explicit components of the elaboration theory include use of synthesizers to show interrelationships between content. The epitome lesson explicitly conveys the structure of the content by providing a special type of overview	Textbooks Individualized instruction Courses	The elaboration theory prescribes a simple to complex sequence which is hypothesized to build stable cognitive structures and provide for meaningful "application level" learning at the outset of instruction.	Limited empirical verification of the effectiveness and efficiency of elaboration sequences. Elaboration sequences are relatively difficult to construct

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Advance Organizers D. Ausubel	Purpose: to facilitate the learning and retention of meaningful verbal information. Based on Ausubel's Subsumption Theory of meaningful verbal learning which suggested that cognitive structure is hierarchically organized in terms of highly inclusive concepts under which are subsumed less inclusive concepts and informational data. Presented in advance od the material-to-be-learned and at a higher level of abstraction, generality and inclusiveness. Expository Form: provides relevant proximate subsumers. Used when material is unfamiliar and no concepts are known to which new ones can be anchored. Comparative Form: integrates new concepts with basically similar concepts in cognitive structure. Used when learners are familiar with material to which new concepts can be anchored. Must clearly delineate similarities between those and material-to-be-learned.	Adjunct instructional aid designed for use in expository (didactic) instruction. Best used with material which is poorly organized, difficult or unfamiliar to the reader in order to increase the discriminability of that material. Best used when the learner's ability is limited as the advance organizer facilitates the construction of an ideational framework for understanding - a weakness for low ability learners (It should be noted that the research evidence for this is equivocal). Most effective in the facilitation of long term retention.	Theory-based. Provides a meaningful context to the learner and encourages the use of that content. Can take several forms including textual verbal passages, diagrams. illustrations, concrete models, analogies, examples, sets of higher order rules, oral and visual presentations. Effective with a variety of age groups and for a wide range of subject matter.	No strong evidence for the effectiveness of advance organizers despite considerable research. Many of the most striking results conflict with the assumptions of Subsumption Theory. Advance organizers are difficult to construct. It is seldom clear what entails material at a "higher level of abstractness, inclusiveness or generality" nor is it simple to determine if the organizer will be sufficient to provide the learner with the appropriate "ideational scaffolding".

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Graphic Organizer: Structured Overview R. Barron	Introduced as a modification of the advance organizer to improve reading instruction. Presented in the form of a tree diagram to introduce new vocabulary to be used in the material-to-be-learned. Uses the spatial characteristics of diagrams to indicate the relationships and distances between key terms.	Vocabulary instruction. Adjunct instructional aid to improve the comprehension of textual material. Can be used pre- or post-reading. Research indicates that the latter is more effective and that structured overviews do affect learning.	Can be used to activate prior knowledge. Students can construct their own structured overviews thus allowing the technique to be generative in nature.	No real basis in theory. Structured overviews are not true advance organizers as originally claimed since they are presented at the same level as the material-to-be-learned. Only presents vocabulary to be used in the passage. No description of the relationship between concepts, principles, etc., to be encountered.
Pictorial Graphic Organizer P. Hawk, M. McLeod and D. Jonassen	An extension of structured overviews. More pictorial or visual in nature. Focus is on key concepts rather than key terms. Uses the spatial characteristics of diagrams to indicate the relationships and distances between key terms. Participatory form: space is left for the learner to fill in key terms and details. Final form: the information is filled in for the learner.	Adjunct instructional aid to provide additional structure to the material-to-be-learned. Can provide a graphic synopsis of the structural interrelationships between ideas in the material-to-be-learned. Can provide a post organizer to summarize what has been learned. Can be used as a diagnostic tool to assess student learning.	Some basis in theory; i.e. Ausubel's Subsumption Theory of meaningful verbal learning via the process of integrative reconciliation. Provides the learner with advance notice of the structure of the material-to-be-learned. Provides a moderately generative learning activity. an overall structure is provided but the learner must define terms and choose what to fill in.	Not yet strongly validated in terms of research evidence. Require some training to learn to construct. Time-consuming to produce. Also, the format is not entirely clear and is subject to wide interpretation. No specific guidelines about the logical structure of the organizer although several are suggested; e.g. chronological order, simple-to-complex sequence, cause/effect.

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Structured Note-taking P.Smith and G. Tompkins	Graphic organizer in which the top level structure used by the author or inferred by the reader is explicit in the graphic. Not as pictorial in format as the pictorial graphic organizer explained above. Provides seven organizers for common text structures: - description - time/order - cause/effect - problem/solution - problem/solution/result - comparison/contrast - definition/examples	Adjunct instructional aid to provide additional structure to the material-to-be-learned. Can provide a graphic synopsis of the structural interrelationships between ideas in the material-to-be-learned. Can provide a post organizer to summarize what has been learned. Can be used as a diagnostic tool to assess student learning.	Some basis in theory; i.e. Ausubel's Subsumption Theory of meaningful verbal learning via the process of integrative reconciliation. Can provide the learner with advance notice of the structure of the material-to-be-learned if presented with an instructor generated version. If learner constructed, is an activity which is strongly generative in nature as the learner must apply the different structures to the material.	Appears to be no research evidence to validate this relatively recent technique. Requires training to be used effectively.

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Concept Maps J. Novak and B. Gowin	Schematic devices for representing the relationships between concepts centered around key topics. Represent meaningful relationships in the form of propositions (2 or more concept labels linked by words in a semantic unit). Include concept labels and propositional statements along the links. Are hierarchical in format as they adhere to Ausubel's Subsumption Theory in which higher order (broader/more inclusive) concepts subsume new concepts or concept meanings with more specific/less inclusive underneath. Use arrows to indicate links which are not superordinate/subordinate.	As graphic organizers to allow the learner to focus on key ideas in a learning task. As post organizers to provide a schematic summary of what was learned. As a creative activity to foster recognition of new concepts. A study technique for students to review material learned or extract meaning from text. An outlining technique for preparing a paper or presentation.	If learner constructed, is an activity which is strongly generative in nature as the learner must construct meaning from the material. Provides graphic representation which can be discussed and/or altered. Novak and Gowin see it as a tool for negotiating meanings. Subtleties of meanings are provided by linking words can be revealing of student's cognitive organization. Scoring system provided which presents a method of assessing the significance of the map constructed.	Hierarchical nature may be limiting and force unnecessary structure. Requires training to use effectively; for instance, learning the difference between concept labels and linking words, choosing appropriate linking words, learning to effectively cluster the concepts, etc. Are time-consuming to construct as the development of symmetry in the map and proper clustering of the concepts may require considerable redrawing of the map. Linking words must be carefully chosen as the meanings presented can vary considerably with the term selected; e.g. the links between the concepts of "water" and "ice" could labelled in many ways including "can be", "becomes" and "sometimes is". Scoring system requires subjective judgments of meaningfulness and validity of concept relationships and cross links.

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	**DESCRIPTION**	**APPLICATIONS**	**ADVANTAGES**	**DISADVANTAGES**
Cognitive Maps G. Diekhoff and K. Diekhoff	Instructor selects key concepts, terms, important events or ideas from the knowledge domain. These are arranged into pairs in matrix form. The pairs are assigned a rating from 1 (no relationship) to 9 (very strong relationship) which is converted to decimal form. A principle components analysis is performed which translates the relationship judgments to distances (highly related ideas close together and less related ones more distant). The distances are used to create the "cognitive map" - a graphic array of concept points in space.	As graphic organizers to allow the learner to focus on key ideas in a learning task. As post organizers to provide a schematic summary of what was learned.	Provide a review of prior knowledge for students. Assignment of "strength of relationship" ratings allows statistical analysis of the maps. This has led to validation of the technique indicating: 1) enhanced student essay scores. 2) increased reliability of student generated judgments. 3) increased similarity between student relationship judgments and those of the instructor.	Provide a relatively passive interaction. Not highly generative in nature. Technique requires a fairly sophisticated statistical manipulation. Cognitive maps are fairly difficult to generate and, hence, not useful as a study technique or as a technique for preparing papers, presentations, etc. Judgment of the strength of relationship between the concepts, terms, etc., is arbitrary. No guidelines provided concerning how to judge. No indication of the nature of the relationship.

Structural Knowledge
LEARNING STRATEGIES

Strategy	Description	Procedure	Uses	Advantages	Disadvantages
STRUCTURAL MAPS	Graphically represent relationships between concepts or ideas.		•note-taking •organize/reorganize information •identify important concepts (ideas) and relationships		
Pattern Notes	Organizes information in a relational manner showing linkages between topics.	•begin with central idea blocked in center of blank page. •free-associate about the subject adding lines containing related ideas. •keep elaborating on these secondary ideas.	•study technique (relationships/self-assessment) •outlining technique (note-taking and response structuring)	•easily learned by a variety of learners •allows for multiple relationships •less constraining more individual (unique)	do not depict the nature of the relationship (except inferred)
Semantic Analysis of Pattern Notes	Post-hoc classification of the links (semantic relationships) between ideas on a pattern note.	application of an algorithm (series of questions) resulting in the classification of the semantic relationship between ideas	to identify the types of relationships between the concepts (ideas) in a pattern note	allows exploration of the nature of the relationships between ideas in a pattern note	not easily used by young learners

Structural Knowledge Learning Strategies

Strategy	Description	Procedure	Uses	Advantages	Disadvantages
Concept Maps	Graphically displays relationships between concepts in a hierarchical fashion.	•extract concepts from material •identify relationships •map top down	•self-assessment •analytical tool for extracting meaning from text, notes, also for understanding literary worth •facilitates paraphrasing •notetaking •response-structuring	•depicts relationships between concepts •promotes meaningful understanding	more constraining than pattern notes
Networking	A spatial organization of material into node-link maps or networks.	•identify important concepts or ideas (nodes) in the material •represent their interrelationships (links) using a set of named links to code relationships	•outlining technique •organizing/manipulating problem space •facilitate problem-solving	•assists in viewing overall concept •links may aid in retrieval	more constraining than pattern noting
Analysis of Key Ideas	Structural alternative to networking aided by worksheets which specify categories of definition and comparison.	•identify key ideas/concepts •develop systematic definitions and elaborations of the concepts •interrelate important pairs of concepts	•(see networking) •elaborate, compare concepts	helpful for learners requiring structure or who have limited study skills	more structured/constraining

Structural Knowledge Learning Strategies

Strategy	Description	Procedure	Uses	Advantages	Disadvantages
NAIT (the Node Acquisition and Integration Technique)	A structured semantic networking technique.	•identify important concepts •describe the links between concepts •completion of definition worksheets which require learners to identify six types of relationships for each key concept; characteristics and descriptors, antecedents, consequences, evidence, subsets, supersets •comparison worksheets (compare/contrast concepts)	•production of more complete concept definitions •integration of information	•learners produce more varied and complete definitions •learners integrate new information •aids in identifying what is most important in a passage	•time •training

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Reading Time Tests	A sentence is broken into propositions by the experimenter. Subject's reading time is measured and correlated with the number of propositions.	Construct Validity of propositions	Easily Administered	Usually limited to laboratory use. Timing devices required.	Propositions
Semantic Recall Tests	Subjects are given paragraph. Later are given sentences and are asked whether or not they have seen the sentence before.	Construct Validity of semantic theories of memory	Easily Administered	Usually limited to laboratory use.	Propositions and semantic theories
Hierarchical Timing Tests	Measured with timing tests using concepts at various levels of generality.	Construct validity of hierarchical memory	Easily Adminstered	Usually limited to laboratory use. Timing Devices are needed.	Hierarchical concept structure
Pattern Notes	Subjects are asked to free associate on paper to a given word. Scored by counting number of links between words.	Assessing complex knowledge structures	Easily Administered and can be interpreted intuitively	Links (relationships) between concepts are not labeled	Structure of schema

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Free Word Association Tests	Subjects are given a word and are asked to list the first word that comes to mind. Below it, the second word, etc.	Assess cognitive structure and correlate with content structure	Easily Administered	Relationships are not explained	Structure of schema
Controlled Word Association Tests	Subjects are given a list of words and asked to rank order them according to which words are most related in meaning.	Assess cognitive structure and correlate with content structure	Easily Administered. Can be interpreted intuitively	Relationships are not explained	Structure of schema
Tree Construction Tasks	Subjects construct a linear graph in which the intersections are words and the connecting lines are relationships	Assess cognitive structure	Easily Administered	Relationships are not explained	Structure of schema
Concept maps	Subjects are asked to link concepts that relate and label the links. A scoring system exists which can relate map to content structure.	Assess cognitive structure and correlate with content structure	Labeled links make relationships explicit	Scoring system is linked to content structure	Structure of schema

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Membership Decision Tasks	Subjects are timed as they decide whether an action is involved in performing a given activity.	Assessment of contents of an individual's script. Build script "norms"	Easily administered	All possibilities must be prepared	Scripts or Schema
Generating Examples	Subjects are given a category and asked to generate members or instances of the category.	Judge semantic proximity between class and examples	Easily administered	May interact with general ability to generate examples	Semantic proximity of concepts
Conceptual Models	Concept maps of content structure.	Assess content structure	Easily administered	Disagreement among experts in loosely defined fields	Content Structure
Concept Typicality Ratings	Subjects are given a superordinate category and are asked to rate the typicality of given instances.	Judge semantic proximity between class and examples	Easily administered	Many possibilities must be prepared	Semantic proximity of concepts
Subtraction Technique	Time to complete a task is compared with time to complete a similar task with one element varied. Assumed that difference is caused by different processing.	Assess information processing models	Usable way to assess a covert system	Laboratory measurement is necessary. Relies on inferences as to actual processes involved	Productions and production systems

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Actual Tasks	Subjects perform tasks that require automatic performance.	Infers the existence of productions that underlie performance	Easily judged visually	Relies on logic of inference	Productions or Executive routine
Think-Aloud Tasks	Subject is asked to speak aloud thoughts as he carries out activity or solves a problem.	Assess problem solving strategies or production systems	Makes covert activities visible	Speaking aloud may interfere with thought process or may inhibit natural processes	Productions, production systems, or problem solving strategies
Diagnostic Tests	Carefully created tests that measure components of a process rather than just the outcome.	Assess missing steps of a production system	Are natural to learner if introduced early in instruction		Productions and production systems
Scanning Time	Subjects are timed as they scan "mental pictures."	Construct validity of pictorial memory		Laboratory timing required	Pictorial memory
Mazes	Lab animals are shown various routes and alternatives paths to accomplish goals.	Assess presence or absence of cognitive maps	Visually scored	Questionable external validity as applied to humans	Cognitive maps, pictorial memory, episodic memory

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Human Mazes	Subjects are put through a disorienting situation and then asked to point to a specific object or a general direction	Assess spatial abilities and sense of direction	Easily administered		Spatial knowledge sense of direction
Field and Ground Tests	Subjects sit in darkened room in movable chair and are asked to orient themselves with a horizon	To determine field dependence or field independence	Replicable and realistic results. Correlation to simpler tests, such as embedded figures test	Complex testing equipment required	Field dependence Field independence or spatial knowledge
Mental Rotation Tasks	Subject is given two pictures of an object and asked to determine whether or not the object in the first picture can be rotated to look like the second one	Construct validity of spatial or pictorial memory. Measurement of pictorial skills	Points to otherwise hidden ability	May require timing devices	Pictorial or spatial knowledge or skills

Title:

Analyzing Automated Instructional Systems: Metaphors from Related Design Professions

Authors:

David H. Jonassen
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Abstract

Automation has impacted virtually every manufacturing and information operation in the world. Instructional design (ID) is no exception. In this article, we suggest three basic metaphors for automating instructional design activities, each typifying different kinds of systems. Within this framework, we describe several prototype systems designed to automate different functions of the ID process. Prospects for future systems are discussed, including criteria for evaluating automated ID systems, and the need for continuing research in ID problem-solving activities.

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Analyzing Automated Instructional Design Systems: Metaphors from Related Design Professions

The instructional design (ID) process comprises the procedures, decisions, and knowledge necessary to plan, develop, and evaluate instructional systems and programs. Actually, the process itself can be seen historically as a step toward automation and control of a complex, costly, and diffuse enterprise. It grew out of efforts in the 1950s and 60s within military and university settings to define systematic methods for engineering instructional products, drawing on ideas from general systems theory, psychology, and management science. The thinking was that, at a time when systems design methods were being used to develop sophisticated weapons and manufacturing products, might the same general design principles be used in the design of complex training systems? Models were developed that proceeded systematically from instructional needs and goals toward design of products. Continuing evaluation and testing were core features of these models, as was the idea that all parts of an instructional system should fit together and contribute to the goals of instruction. Today dozens of different ID models are being used to guide the design and development of training products in a variety of public and private sector organizations.

The next major chapter in the history of ID models is presently being written as ID models are being incorporated more completely into integrated computer-based systems for design and production. Presently, several such prototype systems are being developed that further automate ID processes; we will report on some of those systems in this chapter, and provide reference information on other systems. An additional purpose of the chapter is to analyze different kinds of automated systems, to suggest appropriate roles for these systems, and to point to future directions and needed research.

One way of thinking about the problem is to compare the ID process to similar manufacturing or programming design processes. Gibbons and O'Neal (1988a) state:

> Instructional design belongs to the same family of processes that creates building, car, and widget design...During both design processes, the goals of design turn into functions to be performed by the product, which ultimately materialize as

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> features. This links features directly to original design goals. Documentation of the design...moves from general expressions of intent and form to detailed expressions of function and finally to exacting specifications for individually catalogued products.

Something can be learned by examining design models in engineering and other design fields. Automated approaches used in these fields can serve as metaphors for ID systems. In the section below, we discuss three different design metaphors that serve as a framework for describing automated ID systems: (1) computer-aided design and manufacturing (CAD/CAM) systems, (2) expert system advisor systems, and (3) computer-aided systems engineering (CASE) tools used in programming and information systems design.

The CAD/CAM Metaphor: ID Environments

CAD/CAM systems include graphics design and data manipulation tools that facilitate the engineering and design of products. The flexibility of these tools allows engineers the freedom to conceptually try out different solutions and quickly and easily make adjustments in a product's structure or dimensions. The engineer using CAD/CAM tools has more power and flexibility than predecessors using traditional tools and instruments.

Not surprisingly, CAD/CAM tools have drastically changed the engineer's job requirements over the last 10 years. Their dramatic rise in use has virtually eliminated the need for traditional draftsmen, drawing tables, squares, and compasses. These changes, of course, have been reflected in schools of engineering around the world, and in the individual engineer's continuing professional education. CAD/CAD tools do not replace the engineer's design expertise; rather they provide a fertile problem-solving environment for professionals to do their jobs better.

The IDioM System

An ID tool designed to emulate a CAD/CAM tool would be designed for professional instructional designers in a way that would allow considerable flexibility and support. As an example, consider the IDioM system developed for Apple Computer, Inc. (Gustafson & Reeves, 1988). IDioM is essentially a shell or superstructure, written in HyperCard, that oversees ID processes on a Macintosh computer. Within IDioM, instructional design is conceptualized as having 7 main functions, each with several sub-functions or activities. The 7 functions and their associated activities are shown in Table 1.

Insert Table 1 about here.

The IDioM system makes full use of an array of Macintosh applications, such as Excel, More, and PageMaker. At any point, the designer may be within a tool application--say MacProject II, but is also thought to be within a specific IDioM function and activity, such as **select media** within the **Design Function**. The designer has access to three special menus: the general IDioM Menu, the Manage Menu, and the Help Menu. The IDioM Menu provides orienting and guidance information for working within the system and its various functions and activities. The Manage Menu includes further guidance on planning and reporting progress to others. The Help Menu provides information needed for navigating through the system and connecting to the next logical tool or activity. The Help Menu also allows the recording of personal comments, for use in editing and reviewing work.

The IDioM system seems to fit a CAD/CAM type of design model because it is designed primarily to address the needs of professional designers. It imposes a certain structure on development by incorporating basic ID concepts, but still allows considerable flexibility in specifics of design and production. The designer has available a number of data-organizing and production tools to use at any point in the design process. Help and support is provided, but not in a way to severely constrain the designer's personal style. The IDioM system is now being called ID Library by Apple, and is being beta tested at 6 public and private sector locations (Gustafson & Reeves, 1990).

The Instructional Design Data Base

Another prototype that seems to fit the CAD/CAM model is the Instructional Design Data Base developed by designers at WICAT Systems (Gibbons & O'Neal, 1988b). This product is meant to eventually provide ID tools that encompass the entire ID process. Presently a Task Analysis Interface has been developed for MS-DOS computers (Gibbons, O'Neal, & Monson, 1988) that allows designers to generate either text-based or graphic hierarchical analyses. These analyses are stored within the system and may be sorted, searched, and modified. Although our understanding of the system is based on the operation of the Task Analysis Interface and written descriptions of the larger system, the key to the larger system is the idea of an ID database. Instructional designers work through a successive series of representations of content--needs statements, task analyses, goals and objectives, test items, instructional displays, etc. All of these content representations are interrelated and should be linked together. Changes in one data type should be reflected in changes in the entire system. This core notion of database drives the design and planned capabilities of the overall system.

The CAD/CAM metaphor is apt in describing the Instructional Design Data Base because the system is aimed at the professional designer and offers a measure of flexibility within the constraints of the database. The object of the system is to provide a productive environment within which the designer can perform design-related tasks in an efficient and productive manner. Presently, the ID database concept is being incorporated more completely into another proprietary WICAT product. No information is presently available concerning this new product.

Expert Systems Tools: ID Advisors

Expert systems are decisionmaking tools that make use of reasoning mechanisms developed by artificial intelligence researchers (Grabinger, Wilson, & Jonassen, in press). Most expert systems have a system of IF-THEN rules that constitute the knowledge in a narrow domain. These rules comprise the system's "knowledge base," which is then used to arrive at judgments about what to do in a given situation. The computer program thus becomes an "advisor" to the user, recommending a course of action or choice based on the available data. Expert system advisors typically engage the user in a consultation in which the user responds to questions by providing information about the specific case in hand. The advisor applies that information to its knowledge base and returns with a recommendation or decision. Successful expert systems have been developed for decisionmaking tasks such as diagnosing an illness, choosing a site to drill a well, or troubleshooting a complex piece of equipment (Harmon and King, 1985).

Another way of thinking about expert systems is as an intelligent job aid. Job aids, in the form of checklists, flowcharts, or step-by-step instructions, are written tools or helps to support job performance; that is also essentially the role of expert system advisors (Welsh and Wilson, 1987). On this view, expert system advisors do not provide a complete working environment for doing the entire job; instead, they are occasionally consulted in addressing specific tasks where the user needs special support or expertise. Job aids may be used by professionals in working with seldom-encountered or complex tasks, but more frequently are designed for the novice worker who needs additional reminding and support for specific tasks. As the novice continues on the job and performs the task repeatedly, the need for the job aid may disappear.

Park Row ID Tools

Park Row is a software development and publishing firm founded by Greg Kearsley, who has developed a series of stand-alone expert system rule bases to perform a variety of instructional design tasks. The **Behavioral Objectives** system prompts the user to provide information about expected outcomes which it then assembles into an objective. The system then queries the user to analyze the objective and then classifies it using Bloom's taxonomy of objectives. **Problem Analysis** provides advice on which of several data gathering techniques, such as fault tree analysis, interviews, focus groups, etc., to use in performing a job analysis. **CBT Analyst** leads the user through a series of decisions to determine whether or not to develop computer-based training. **Cost/Benefits Analysis** queries the user for information about a prospective training situation. The information is then sent to a spreadsheet to estimate the costs and benefits of developing training. Most of these systems were written in Turbo Pascal and run in an MS-DOS environment with minimal memory requirements.

The Park Row tools fit clearly into the advisor or intelligent job aid category. Each tool provides only analysis and/or advice about the ID process, rather than an actual production environment. The tools may be found useful by professional designers, but would more specifically help the novice designer or technician in need of greater structure and expertise.

CASE TOOLS: Computer-aided ID

Within the last 5-10 years, a category of software tool has attracted attention among systems designers and programmers. CASE (computer-aided systems engineering) tools are programs that automate the programming process (Bigelow, 1988), sometimes referred to as code generators or applications generators. In concept, a user would use a CASE tool by specifying the inputs and desired outputs for a given product, along with other constraints, and the computer would automatically generate fully written code for that product. Although that goal sounds idealistic, some progress has been made in developing systems that compile code to meet specified needs. The idea is similar to a programmer who compiles code blocks from a library of routines rather than starting from scratch on a new project. Much of the programming work has already been done and is available in the form of routines; the job of the programmer is to assemble and fine-tune these routines into a smoothly working program that solves the information/performance problem at hand.

ID Expert

Using the idea of CASE tools for instructional design, we could imagine a product that inputs information about the context, content, learner, etc., and then automatically compiles a specific instructional plan or product. ID Expert, although in its initial stages, is a system that philosophically bears some resemblance to this notion. ID Expert is being developed for the Army Research Institute by M. David Merrill and Zhongmin Li of Utah State University and Human Technology, Inc. of McLean, Virginia under contract with the U.S. Office of Personnel Management, Office of Training Development. It is a combined consultation and production system which provides analysis of content and instructional strategies. In the current phase of development, it is implemented in HyperCrad from Apple and Nexpert from Neuron Data for the Macintosh family of computers. The current version is being tied to the Research Reference Interface, a hypertext system that provides reference information on the theory, policy, empirical support, and logic used by ID Expert. Like ID Expert, RRI is screen-oriented and menu-driven and is written in HyperCard. ID Expert consists of several modules:

- an information gathering module that queries the user on content to be taught and relevant learner characteristics (such as motivation level and prior knowledge);
- a reasoning model that uses the information gathered to create and reason with rules in Nexpert's inference engine;
- a specification module that presents advice on course and content structure and the required instructional strategies;
- an authoring module for creating instructional sequences; and
- an explanation module which explains the rule base and connects to RRI.

ID Expert begins by querying the designer about the title, audience attributes, the goal and its attributes, and recommends an appropriate content structure. Next the system queries the designer about specific content attributes and elaborates the content structure while recommending a course organization, instructional strategies, and individual instructional transactions. These transactions can then be created and sequenced in the authoring module.

Unlike most other automated ID systems, ID expert builds in considerable theory. Based on elaboration theory for its course level strategies (Reigeluth & Stein, 1983) and component design theory for developing micro-level strategies (Merrill, 1987), the system offers designers much more specific and concrete support for selecting instructional strategies based on type of learning outcome than is available in other systems. It is in this sense that ID Expert resembles programming CASE tools. The designer supplies information about a given problem, then ID expert is meant to compile the pieces into a coherent instructional strategy. In a sense, ID Expert's ambition is to automate the process to the point that the computer provides essential expertise for designing instructional products, leaving less discretion in the hands of individual designers.

Returning to our discussion of CASE tools for a moment, although the idea of automatic code generators obviously has appeal, forecasts and promises of such tools have exceeded actual delivery performance of tools developed to date. The problem is complex, particularly because programs must be developed in specific contexts with constraints that are often unique. This means that programs produced automatically following a generic pattern must inevitably be adjusted and changed to fit the new situation. The fine-tuning and changing that must be done often approach in complexity the task of programming from scratch. The ambition of a program like ID Expert may face similar obstacles. The state of research and theory in instructional design may not be able to hold up the platform of decisionmaking upon which ID Expert is built. Although very explicit and guided systems such as ID Expert are a tremendous boon to theory development, their practical use may encounter problems similar to those of programming CASE tools.

Mixing the Metaphors: Hybrid Environments

To this point, system types have been described in idealized terms. Of course, many systems cross over and overlap our metaphors. The IDioM system, for example, contains a connections option off the Help Menu that lends itself well to expert systems technology. The system could track where the designer is within IDioM and anticipate the next needed activity or tool. Thus within an overall production environment for instructional design, expert systems can easily have a place.

The same thing can be said for strongly theory-based products. Different theories might be thought of as templates to be superimposed upon a system: At the designer's request, a different model or template could be selected to drive the design. Thus the rigidity of any particular approach is much less threatening to the professional designer, because it can always be thrown out and replaced by another.

It would seem desirable that a design environment combine the best elements of production tools (graphics, text, and video), database and organization capabilities, and expert systems or hypertext technologies where appropriate. Each of the systems discussed above exhibits different strengths in these areas. In the section below, we turn to our own prototype system, the Instructional Design and Development (IDD) Advisor. Presently the system is designed primarily as an advisor and front end to a database; future plans call for its integration with production tools to provide a more complete development environment.

IDD Advisor

The IDD Advisor is an on-going project designed to provide intelligent job aid support for assisting an instructional designer, teacher, or course writer to follow the instructional design and development (IDD) process. The IDD Advisor is also an intelligent front end to a database containing the components of the instructional sequence being developed, so that as instructional decisions are made, the results of those decisions are stored in a database.

The IDD Advisor is a structured rule-based expert system with several rule sets. The arrangement of these rule sets is illustrated in the context tree for the IDD Advisor in Figure 1. Each node represents a separate rule set which, in effect, functions as a separate knowledge base. Each rule set draws on fairly generic and well-established ID concepts.

Insert Figure 1 about here.

The first rule system encountered is the executive menu, which queries the user to ascertain if this is a new design project. If the project is new, it executes the project analysis rule system. If the user is adding onto an existing project, the executive menu enables the user to select the rule system that she or he needs to work in.

For new projects, the user would typically work through a project analysis rule set first. This rule set collects information about the project and establishes whether the project is instigated by a performance problem or whether it involves new systems, automatic training, or educational development. If the project is predicated on a performance problem, the project analysis module will access the performance analysis module. The user will provide information about the nature of the performance problem. For instance, a corporate user might identify employee productivity as a problem. If the project is not problem-based, the project analysis module will access the needs assessment rule set. Regardless of the purpose of the project, the project analysis module

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saves information about the project.

The performance analysis rule set leads the user through a typical performance analysis: identify the goal performance state, the current state, determines the discrepancy, determines the cause and classifies the cause of the performance problem. If the problem is caused by motivational or environmental problems, the user would exit the system. The performance analysis rule base would help the user identify the cause and whether or not training is the proper solution. In the future, motivational and environmental problem rule sets may be developed. If the problem is determined to be a skill/knowledge problem, then the problems are recorded and indexed in the database, and the user is led to the task analysis module.

The needs assessment rule set is accessed if the project analysis determines that the project is not problem-based. If that is the case, users need to decide which data collection instrument is appropriate for conducting the needs assessment. Should they use a questionnaire, interview, focused group or brainstorming session? Users are led through the needs assessment technique which helps them decide why type of instrument is appropriate for their need. Having determined the instrument type, they need to select the question form and question type in order to construct the questions. The outcome of these modules is a needs assessment instrument with the questions identified. This information is then stored in the database. After collecting the data, users would access the needs assessment interpretation rule set to help them interpret the outcome. The users would then be led to the task analysis module.

The task analysis process has three rule sets that assist the user. The first module helps the user select the most appropriate task analysis technique from a list of 27 found in Jonassen, Hannum & Tessmer (1989). A sample of the rules in this rule set is illustrated in Figure 2. The technique rule set may access the tool rule set to determine the most appropriate information gathering tools. Finally, the task analysis rule set will help users to interpret and analyze the information they collect. The sub-tasks will be stored in the database.

Insert Figure 2 about here.

Following the task analysis, the objective writing and test item writing rule sets will access the tasks stored in the database and help the users to convert them to objectives, classify those objectives, and write test items that measure those objectives.

Having developed the test items, designers would then access the instructional design modules, which would help them to select the necessary presentation forms and instructional strategies for the sequence of tasks/objectives determined in the previous modules. Again, the rule sets will interact with the database by pulling the information out of the database and using it to help the users to select the instructional lesson components.

Finally, designers could access the delivery module to access advice on selecting the appropriate delivery system for presenting the instructional components. The system may be expanded to include a message design module in the future.

The prototype knowledge bases run under VP Expert from Paperback Software. VP Expert is a structured, rule-based system with considerable power and flexibility. The information base is being created in dBase III+ from Ashton-Tate. VP Expert can interface with dBase files in order to function as an intelligent front end to the database. Both software packages run on MS-DOS personal computers (IBM or compatible). The reasons for selecting the software packages currently being used to develop IDD Advisor are pragmatic. They are inexpensive, readily available, and commonly used. That makes the system more useful to a wider range of users.

Harmon (1986) describes a seven step process for design, developing, and implementing expert systems.

1) Front end analysis - performance problem and cost benefit

2) Task analysis

3) Prototype development - development of a small version to test feasibility and desirability of system

4) System development - develop entire system

5) Field test the system

6) Implementation - disseminate the system

7) Maintenance - upgrade the system and provide user support

The IDD Advisor is currently at the fourth step in this process --- system development. The task analysis yielded the context tree shown in Figure 1. A prototype of two of the rule sets was demonstrated (Jonassen, 1988). The remainder of the rule sets and the database files need to be developed.

Needed Research on Instructional Design

All of the systems described above incorporate ID concepts and procedures that have proven their worth over the past 25 years in field-based development projects. At the same time, automating these procedures affords a new opportunity to validate the effects of these procedures. With the computer to assist in data gathering and storage, differences between systems can be explored. This in turn can refine our knowledge base regarding effective ID procedures.

While generic ID models have been somewhat validated by practical experience, there is a surprising lack of empirically derived knowledge about the problem-solving heuristics of professional instructional designers. How do individual designers do their work within the overall ID framework? How closely do they follow prescriptions from the models; when do they use their intuition and professional judgment to override conventional ID recommendations? What kinds of learning, management, and design principles do they actually incorporate at various points in the design process? Virtually no formal research has been completed to study these questions, yet an understanding of designers' problem-solving strategies seems extremely relevant to the design of automated ID systems. We also need to be concerned about designers' use of tools: How do designers use computers and other reference/production/organization tools in their work? The designer/computer interface needs to be more thoroughly studied before automated ID systems can be optimized.

Rather than be stymied by our lack of knowledge in these areas, we should see the advent of automated ID systems as opportunities to conduct in-depth studies and examine processes in closer detail. Thus, in the long run, automated ID systems will not only incorporate our present knowledge of ID, but also contribute to that knowledge in the future. In the same way that cognitive science researchers develop computer-based models of cognitive processes, instructional designers will come to view the development of automated ID systems as a valuable method of research and a way to contribute to our knowledge base about instruction.

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Table and Figure Captions

Table 1. IDioM Functions and Activities (from Gustafson & Reeves, 1988).

Figure 2. Context tree for the IDD Advisor. Shaded boxes are presently not developed.

Figure 3. Sample rules from the IDD Advisor.

FUNCTION	ACTIVITY
ANALYZE	Conduct needs and goal assessment
	Define learner characteristics
	Conduct task analysis
	Examine existing materials
	Conduct financial analysis
DESIGN	Specify objectives
	Sequence objectives
	Determine strategy
	Select media
	Prepare assessment
DEVELOP	Define lesson treatment
	Outline content
	Prepare training materials
	Integrate interactive media
EVALUATE	Collect project documentation data
	Assess worth of training objectives
	Conduct formative evaluation
	Assess immediate effectiveness
	Evaluate training impact
	Estimate cost effectiveness
IMPLEMENT	Prepare implementation plan
	Communicate with Training Center
	Support implementation
	Train the trainer
PRODUCE	Prepare component list and estimate
	Prepare packaging
	Specify and order components
	Assemble package
	Debrief
MANAGE	Estimate project scope
	Start up with project

Table 1. Functions and Activities from the IDioM environment, presently called the ID Library (from Gustafson & Reeves, 1988).

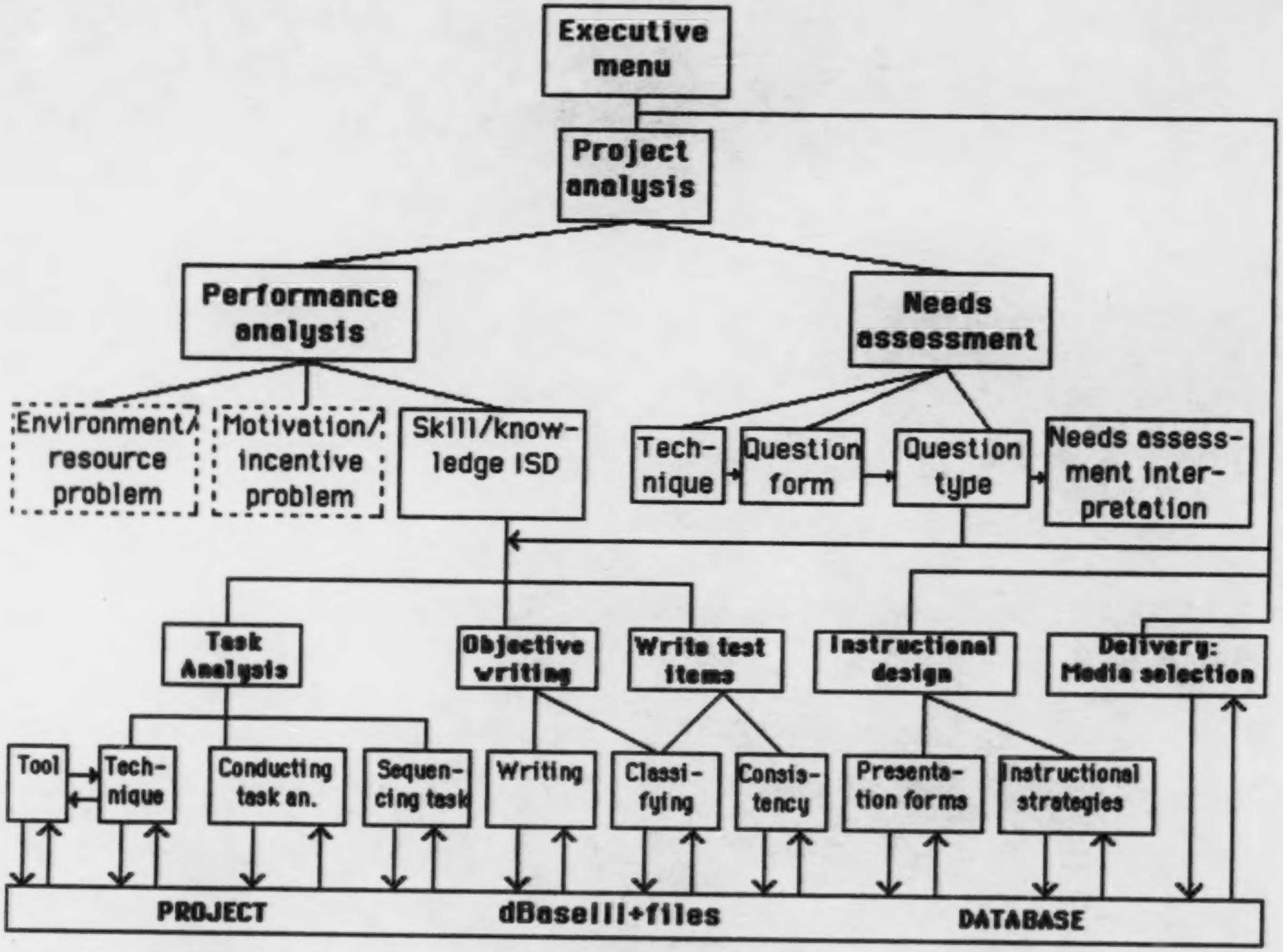
Executive menu
Project analysis
Performance analysis
Needs assessment
Environment/ resource problem
Motivation/ incentive problem
Skill/know- ledge ISD
Tech- nique
Question form
Question type
Needs assess- ment inter- pretation
Task Analysis
Objective writing
Write test items
Instructional design
Delivery: Media selection
Tool
Tech- nique
Conducting task an.
Sequen- cing task
Writing
Classi- fying
Consis- tency
Presenta- tion forms
Instructional strategies
PROJECT
dBaseIII+files
DATABASE

Figure 2
Rules for Selecting Task Analysis Techniques

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IF          Type-Job AND
            Scope-Single AND
            Function-Sequence AND
            Cost_Time-Low AND
            Expertise-High
THEN        Technique-Learning_Contingency_Analysis;

RULE 12
IF          Type-Job AND
            Scope-Single AND
            Function-Description AND
            Cost_Time-Low AND
            Expertise-Low
THEN        Technique-Behavioral_Analysis;

RULE 13
IF          Type-Job AND
            Scope-Single AND
            Function-Description AND
            Cost_Time-High AND
            Expertise-High
THEN        Technique-Functional_Job_Analysis;

RULE14
IF          Type-Job AND
            Scope-Single AND
            Function-Description AND
            Cost_Time-Low AND
            Expertise-High
THEN        Technique-Learning_Contingency_Analysis;

RULE 15
IF          Type-Job AND
            Scope-Single AND
            Function-Description AND
            Cost_Time-Low AND
            Expertise-Low
THEN        Technique-Methods_Analysis;

RULE 16
IF          Type-Job AND
            Scope-Single AND
            Function-Description AND
            Cost_Time-Low AND
            Expertise-Low
THEN        Technique-Task Description;
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Title:

Providing Practice using Instructional Gaming: A Motivating Alternative

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Providing Practice using Instructional Gaming: A Motivating Alternative

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Paper presented at the 1990 AECT Annual Convention
Anaheim, CA   February, 1990

Providing students with an opportunity to practice newly acquired skills and knowledge is an important component in designing an instructional strategy. While many instructional design theories include recommendations for designing practice activities, Salisbury, Richards, and Klein (1985) point out that most of these theories fail to address how to design practice that is motivational.

A number of educators argue that instructional games are effective for providing motivating practice of newly acquired skills and information. These scholars argue that instructional games are motivational because they generate enthusiasm, excitement, and enjoyment and because they require students to be actively involved in learning (Coleman, 1968; Ernest, 1986; Rakes & Kutzman, 1982; Wesson, Wilson, & Mandlebaum, 1988). Other scholars argue that instructional games decrease student motivation. These authors believe that the motivational aspects of instructional games are limited to those who win, and that losing an instructional game produces a failure syndrome and reduces self esteem (Allington & Strange, 1977; Andrews & Thorpe, 1977).

While theorists argue about the motivational aspects of instructional games, researchers have investigated the effect of using games on student motivation. The results of these studies are inconclusive. Some researchers report that the use of instructional gaming increases student interest, satisfaction, and continuing motivation (Devries & Edwards, 1973; Sleet, 1985; Straus, 1986). Others report that playing a game does not influence student satisfaction or attitude toward school (Devries & Slavin, 1978). Investigators also report that instructional games influence school attendance. Allen and Main (1976) found that including instructional gaming in a mathematics curriculum helped to reduce the rate of absenteeism of students in inner-city schools. Studies by Raia (1966) and Boseman and Schellenberger (1974) indicated that including games in a college business course has a positive affect on course attendance but not on expressed interest and satisfaction.

In addition to the possible motivational benefits instructional games, educators believe that games are effective for helping students learn. Scholars argue that instructional games make practice more effective because students become active participants in the learning process (Ernest, 1986; Rakes & Kutzman, 1982; Wesson, Wilson, & Mandlebaum, 1988). Others argue that games foster incorrect responding, are an inefficient use of instructional time, and that the rate of practice in a game cannot compare to a flashcard drill or reading a connected text (Allington & Strange, 1977; Andrews & Thorpe, 1977).

Researchers have attempted to answer whether instructional games are an effective method for learning. The results of these studies are inconclusive. Some investigators report that instructional games are effective for assisting students to acquire, practice, and transfer mathematical concepts and problem solving abilities (Bright, 1980; Bright & Harvey, 1982; Bright, Harvey, & Wheeler, 1979; Devries & Slavin, 1978; Dienes, 1962; Rogers & Miller, 1984). Others report that using an instructional game to practice math skills assists slow learners but not more able students (Friedlander, 1977). Research on the use of instructional games in college business courses has produced inconclusive or nonsignificant finding in many studies (Boseman & Schellenberger, 1974; Greenlaw and Wyman, 1973; Raia, 1966), while instructional games have positively influenced learning in actual business training settings (Jacobs & Baum, 1987; Pierfy, 1977). Even advocates of instructional gaming believe that there is some disagreement over whether games teach intellectual content and skills (Boocock, 1968).

There are several explanations for the inconsistent findings from research concerning the effect of instructional games on motivation and learning. One is that much of the research on instructional gaming has been conducted using flawed experimental designs and methods (Reiser & Gerlach, 1977; Remus, 1981; Stone, 1982). Another explanation is that many of the studies on instructional gaming have not investigated the integration of games in an instructional system. Gaming advocates suggest that games should be used with other instructional methods such as lecture and textbooks (Clayton & Rosenbloom, 1968). A third explanation is that researchers examining the effect of instructional gaming on motivation have not adequately defined and operationalized the variable of motivation. After an extensive review of instructional gaming, Wolfe (1985) indicated, "no rigorous research has examined a game's motivational power, [or] what types of students are motivated by games" (p.279).

The purpose of this paper is to describe the results of a study conducted to determine the effects of using an instructional game on student motivation and performance. Motivation was defined using the ARCS model of motivation (Keller, 1987a). This model suggests that motivation in an instructional setting consists of four components: attention, relevance, confidence, and satisfaction. We hypothesized that students using an instructional game to practice newly acquired information would indicate that this method enhanced their attention, relevance, confidence, and satisfaction. In addition, since the study was designed integrate the game into an instructional system, we attempted to determine the effect of using a supplemental reading on student motivation and performance.

Method

Subjects

Subjects were seventy-five undergraduate education majors at a large southwestern university. The students were enrolled in a

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required course in educational psychology and participated in the study to satisfy a course requirement.

Materials

Materials used in this study were an instructional game and a worksheet, both designed to provide practice of information and concepts presented in a lecture, the textbook Essentials of Learning for Instruction by Gagne & Driscoll (1988), the Instructional Materials Motivation Scale (Keller, 1987b), and a measure of performance.

The instructional game was developed by the authors in order to provide subjects with practice on the information-processing model of learning. The instructional game consisted of a game board that graphically represented the information-processing model of learning, a direction card that explained the rules of the game, and a set of 25 game cards. Each game card had a practice question about the information-processing model of learning on the front and feedback with knowledge of correct results on the back.

The worksheet was also developed by the authors to provide subjects with practice on the information-processing model of learning. The worksheet was four pages in length and included the same 25 questions that appeared on the game cards. After subjects completed a set of five questions, the worksheet instructed subjects to turn to the last page for feedback.

The Instructional Materials Motivation Scale (IMMS), developed by Keller (1987b), was used to measure student

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perception of the motivational characteristics of the instructional materials. The IMMS includes four subscales to measure the motivational components of attention, relevance, confidence, and satisfaction. Keller (1987b) reported that Cronbach's alpha reliability of this instrument is .89 for attention, .81 for relevance, .90 for confidence, .92 for satisfaction, and .96 for overall motivation.

A 15 item constructed response posttest was used to measure student performance. The items on this posttest were developed by the authors to determine subject mastery of the information-processing model. The internal consistency reliability of this measure was .77.

Procedures

All of the subjects attended a lecture on the information-processing model of learning and were told to read chapter two in the textbook Essentials of Learning for Instruction by Gagne & Driscoll (1988). Two days later, subjects were randomly assigned to either a treatment or control group. Subjects in both groups were given thirty minutes to practice the information presented in the lecture and assigned reading by using either the instructional game or the worksheet.

Treatment group subjects used the instructional game to practice the information-processing model. After being informed that they would be playing a game, subjects were randomly placed in groups of eight to ten and were asked to form two teams of players. Each group received the game materials described above and the experimenter read the game rules aloud. Subjects were given thirty minutes to play the game.

Subjects in the control group used the worksheet to practice the same items. Each subject worked individually for thirty minutes to complete the worksheet. Subjects were told to review incorrect items if time permitted.

Upon completion of the practice activity, all subjects completed the Instructional Materials Motivation Scale and then took the posttest. Subjects were also asked if they had attended the lecture on the information-processing model and if they had completed the assigned reading from the textbook.

Results

Motivation

Multivariate analysis of variance (MANOVA) was used to test for an overall difference between groups on the motivation scales. An alpha level of .05 was set for the MANOVA tests. These analyses were followed by univariate analyses on each of the four IMMS subscales. In order to account for the possibility of inflated statistical error, alpha was set at .025 for the univariate analyses using the Bonferroni method (Stevens, 1986).

Results indicate that using the instructional game to practice information had a significant effect on motivation. A significant MANOVA effect, $F(4, 64) = 6.57$, $p < .001$ was found for the treatment on the motivation measures. Univariate analyses revealed that subjects who played the game rated this method of practice as motivational in the four areas of attention

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$F(1, 67) = 21.91$, $p < .001$, relevance $F(1, 67) = 15.05$, $p < .001$, confidence $F(1, 67) = 16.80$, $p < .001$, and satisfaction $F(1, 67) = 24.71$, $p < .001$. Table 1 includes a summary of means and standard deviations on each motivation subscale for the game and the non-game groups.

Table 1 about here

Results also suggest that completion of reading assignment had an influence on motivation. A significant MANOVA effect, $F(4, 64) = 2.94$, $p < .05$, was found for this variable on the motivation measures. Follow-up univariate analyses revealed that the motivational area of confidence was significantly affected by completion of reading assignment $F(1, 67) = 6.52$, $p < .025$. Attention, relevance, and satisfaction were not significantly influenced by completion of reading assignment. Means and standard deviations can be found in Table 1.

Performance

Performance was measured using a 15 item constructed response posttest. Analysis of variance (ANOVA) was used to test for differences between groups on the performance measure. An alpha level of .05 was set for all statistical tests.

Results indicate that completion of assigned reading significantly contributed to posttest performance, $F(2, 72) = 14.87$, $p < .001$. Subjects who indicated that they had read the assigned materials significantly performed better on the posttest

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that those who did not complete the reading (see Table 1). While results suggest that subjects in the treatment condition outperformed control group subjects on the posttest, this difference was not statistically significant.

Discussion

The major purpose of this study was to determine the effect of using an instructional game on student motivation and performance. The results of the study suggest that using an instructional game as a method of delivering practice does enhance the motivation of students in the four areas of attention, relevance, confidence, and satisfaction. However, the results show that an instructional game does not necessarily contribute to enhanced performance when it is used to practice information. These results occurred perhaps occurred for several reasons.

The instructional game used in this study provided students with a visual representation of the information-processing model of learning and required them to be active participants in the teaching/learning process. Keller (1987a) indicated that visual representations and active participation are two strategies that can increase student attention in an instructional setting. Furthermore, it is possible that using the game contributed to the results found for attention because of a novelty effect. Some researchers report that student motivation and interest fluctuate and decrease as the novelty effect of a game wears off (Dill, 1961; Greenlaw & Wyman 1973), while others report that interest tends to persist over time in gaming settings (Dill & Doppelt, 1963). While novelty may be a reason for increased attention in this study, this explanation should be considered as positive by instructional designers who are concerned with providing motivating practice to students. Motivation and attention can be increased when variability and novelty are used in the classroom (Keller, 1983, 1987a).

The results found in this study for the motivational factor of relevance is consistent with theory proposed by gaming advocates. These authors argue that students will not question the relevance of educational content when it is presented via an instructional game (Abt, 1968; Rogers & Miller, 1984). In addition, Keller (1983) indicated that instructional designers can make instruction motivational by designing materials that are responsive to the needs of students. Orbach (1979) indicated that games are excellent methods to motivate students with a high need for achievement because a game can include an element of competition. Orbach (1979) also theorized that games can motivate students with a high need for affiliation when the game requires interaction among individuals and teams. The instructional game used in this study included a moderate level of competition and required students to interact through the team approach.

The instructional game used in this study also provided circumstances for student-directed learning. As a motivational strategy, student-centered learning has been linked with

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increased confidence (Keller & Dodge, 1982). The finding that the game increased student confidence is consistent with theorists who suggest that games can influence student efficacy (Abt, 1968) and researchers who report that students rate the task of gaming as less difficult than other instructional techniques (Devries & Edwards, 1973).

The positive finding for satisfaction is also consistent with theory and research. A number of scholars indicate that instructional games contribute to motivation because they provide intrinsic reward and enjoyment (Coleman, 1968; Ernest, 1986; Rakes & Kutzman, 1982). Researchers report that instructional games lead to increases in student satisfaction (Devries & Edwards, 1973; Strauss, 1986). The results of this study support theorists and researchers who suggests that students enjoy the gaming approach in instruction.

While the results did suggest that instructional games have a strong effect on student motivation, the game used in this study did not have a significant impact on student performance. However, subjects completing an assigned reading significantly performed better and had more confidence about their performance than those who did not complete the reading. These results may have occurred due to the nature of the reading. Even though all the students were provided with necessary concepts and information in a lecture, the textbook Essentials of Learning for Instruction by Gagne & Driscoll (1988) provides readers with practice and feedback on the ideas presented in each chapter.

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This additional practice and feedback more than likely influenced both the performance and confidence of those who completed the assigned reading.

The findings of this study have some implications for the design of practice. While many instructional design theorists indicate that students should be provided with an opportunity to practice newly acquired skills and knowledge, most fail to address how to design practice that is motivational (Salisbury, Richards, & Klein, 1985). The results of this study suggest that instructional designers can provide students with a motivating practice alternative that is as effective as more traditional methods of practice. Instructional designers should also include reading assignments that provide additional practice in their instructional strategies to increase student performance and confidence about that performance.

As was done in this study, future research should integrate instructional games into a system to determine if this method has an impact on educational outcomes. Besides using a game as practice, research could be conducted to examine the effect of using a game to present other instructional events such as stimulating recall of prior knowledge or as a review of learning. Researchers of instructional gaming should continue to investigate the effect of using a game on student motivation and should be specific in their operational definition of motivation. Implementation of these suggestions will assist us in determining how to design practice that is both effective and motivational.

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Table 1

Means and Standard Deviations on Attention (A) Relevance (R) Confidence (C) Satisfaction (S) and Performance (P) Measures

Group	A	R	C	S	P
Treatment					
Game	4.22	3.71	4.06	3.88	10.49
n=37	(0.58)	(0.58)	(0.57)	(0.86)	(3.20)
Non Game	3.77	3.13	3.31	2.72	9.39
n=38	(0.89)	(0.69)	(0.90)	(1.02)	(3.60)
Text Reading					
Read	3.81	3.49	3.91	3.34	11.25
n=40	(0.65)	(0.57)	(0.67)	(0.89)	(3.07)
Not Read	3.74	3.34	3.44	3.27	8.45
n=35	(0.84)	(0.68)	(0.61)	(0.99)	(3.22)

Note. Maximum scores = 5.00 for A, R, C, S and 15.00 for P.

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Title:

Visual Discrimination, Learning, and Page Layout: Wrap-Around, Run-Around, and Transparent Text

Authors:

Nancy Nelson Knupfer
Marina Stock McIsaac

Visual Discrimination, Learning, and Page Layout: Wrap-Around, Run-Around, and Transparent Text

As desktop publishing revolutionizes printing and publication, sophisticated computer programs offer the novice a wide range of techniques formerly available only to professional layout artists. Now anyone can design and produce their own instructional materials by transforming existing art into professional quality work that can be pasted into any variety of text formats.

Several popular software programs are noted for versatility and ease of layout design. They not only feature run-around text, but now boast wrap-around text and transparent text features as well. Run-around text is that which is "boxed" around the graphic, maintaining a square border around the visual (see Figure 1). Wrap-around text is that which flows smoothly around the graphic and "hugs it tight", leaving an irregularly shaped border (See Figure 2). Transparent text is that which has a graphic laid over it; the reader reads the text through the graphic (See Figure 3). These formatting features are described by software publishers as desirable software advancements, which allow the designer to quickly and rapidly communicate ideas to the reader. Examples of the use of run-around, wrap-around, and transparent text can be found in consumer magazines, newspapers, and instructional materials. In many instances, legibility appears severely restricted by the haphazard mixture of text and graphics.

Desktop publishing computer programs have individualized the page layout process and have provided sophisticated graphic enhancements for computer users who have no training in either instructional development, page layout, or graphic design. People who use such computer software to design instructional materials are faced with a vast array of newly developed features with no guidelines for their effective use. Guidelines are sometimes provided but they are often confusing. In one guide to basic design, a designer is told to "Frame your pictures with white space...White space separates headlines from surrounding body copy and artwork, making headlines easier to read" (Parker, 1987, pp 42-43). The examples show both run-around and wrap-around features being used.

Teachers and trainers who use computer programs to design instructional materials and integrate visuals in the text are asking for guidelines. How do these new desktop publishing enhancements affect the legibility of text? What is the optimal placement of text and graphics? How and where should white space be located to enhance reading comprehension? At what point does the integration of the text and visual

FIGURE 1
Run-Around Text

In terms of documentation they all do a good job, but *PageMaker* is by far the hardest program to learn to use. For users already familiar with *PageMaker* on the Mac, there will be instant recognition — it's the same program with improvements. For people who haven't struggled to learn it already, they have a long learning time ahead of them. *Spellbinder*, too, requires a long learning period. It's not as complicated as *PageMaker*, but the dot-command structure makes it less intuitive than a program that uses a mouse and icons. With *Spellbinder*, I had to constantly refer to the manual to look up commands, whereas with *Pagemaker*, I had difficulty just going through the complex menu choices. *Ventura* was relatively easy to learn, allowing me to feel in control of the program after a much shorter time. In fact, *Ventura* gave me almost as much pleasure in the thrill of discovery followed by quick satisfaction as *Clickart* did when I first used it. If I had used *Ventura* before *Clickart*, I think I would have been disappointed with *Clickart*.

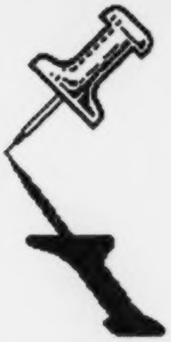

FIGURE 2
Wrap-Around Text

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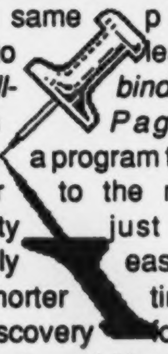
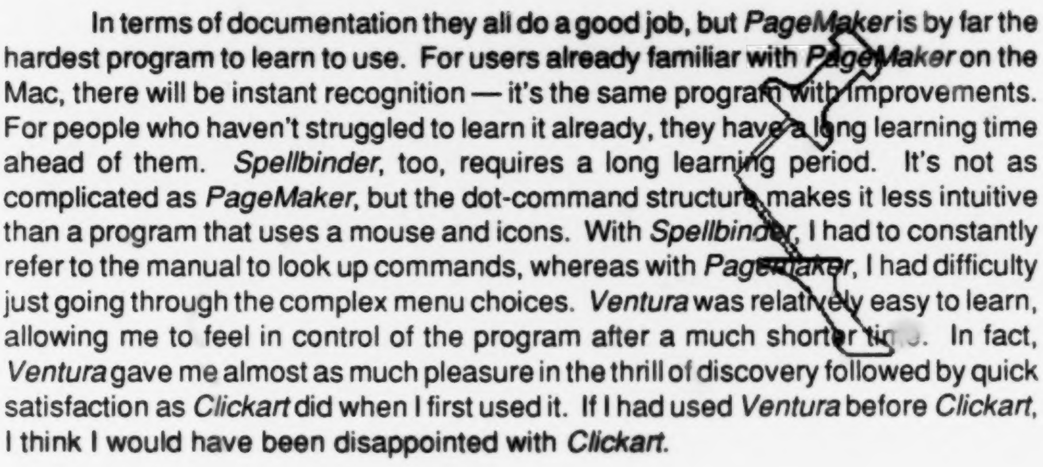


FIGURE 3
Transparent Text



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adversely affect legibility? How close to the visual should the text be placed?

PURPOSE OF THE STUDY

The purpose of this study was to determine the effects of three electronic text variables, run-around, wrap-around, and transparent text, on reading speed and comprehension. Results mights suggest some guidelines for the placement of graphics within electronic text.

Many researchers have investigated layout, typographic cueing, and presentation of graphic materials in instructional text. For example, Hartley (1985) determined that page size affects other layout decisions. Recent studies comparing the effects of justified and unjustified text are inconclusive. For example, Jonassen (1982) reported that in some circumstances, right justified text inhibited comprehension when compared to unjustified text. Yet, Campbell et al. (1981) and Muncer et al. (1986) determined that reading speed and comprehension were not significantly influenced by justification versus nonjustification. Jandreau et al. (1986) investigated the effects of varying spaces between phrases in sentences. And, others have examined certain design features common to printed and electronic text in the presentation of graphic materials (Alesandrini, 1987; Poggenpohl,1985; Winn,1987; Winn & Holliday, 1982). Graphics designers emphasize the importance of using white space for balancing text, positioning graphics as the dominant visual element, and improving the aesthetics of the page layout (Parker, 1987). And, in 1987, Hartley, Isaacs, and others noted a need for published research on the effect of various text-wrap enhancements with either printed or electronic text. There is little reported research on graphic placement in instructional text and none that has produced guidelines for instructional use of graphics with the emerging computer software programs.

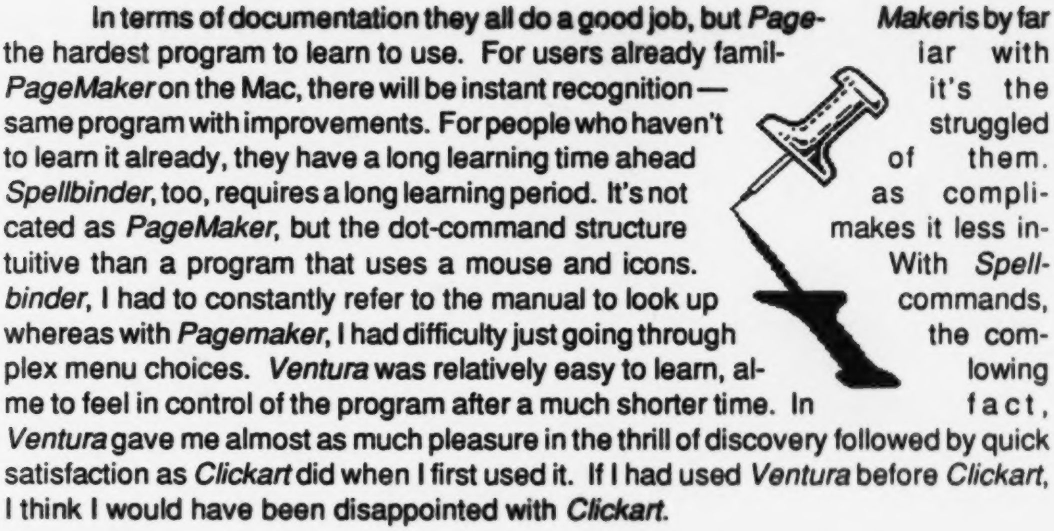
Although certain features of electronic text can be transferred to printed text, there are many differences between the two which suggest that separate studies be conducted. The size of the screen or page, the type size, and the ability to scroll are but a few of the differences which affect print and electronic text comparison studies. Because of these differences, a programmatic series of investigations is needed to examine the effects of these recent technological enhancements in each of the two media formats.

Knupfer and McIsaac (1988) responded to that need by studying the effect of run-around and wrap-around text, within one and two column formats, on reading speed and comprehension. That study found that the number of columns had no significant effect, however the text wrap did make a significant difference. Reading speed was faster and comprehension was better with wrap-around text, as shown in Figure 2, than with run-around text, as shown in Figure 1. In a follow-up study, Knupfer and McIsaac (1989) tried to determine if that difference was due to the amount of white space between the graphic and the text, or due to the shape of the white space surrounding the graphic. The follow-up study tested the variable of white space between the graphic and text by comparing two sets of reading materials which both used wrap-around text only; the difference was that one wrapped the text tightly against the graphic, as shown in Figure 2, while the other conformed the text to the shape of the graphic but left approximately one quarter inch of white space between the graphic and the text, as shown in Figure 4. There were no significant differences between wrap-around text with no white space and wrap-around text with one quarter inch of white space.

This study continues the investigation of text-wrap variables by adding an additional text-wrap feature, transparent text. If the results prove similar, guidelines should then be established to assist teachers and trainers in the appropriate use of this new type of desktop publishing feature. It is hypothesized that the previous results will be replicated and further, that the transparent text will show greater interference with reading speed and comprehension.

Recent work by Morrison, Ross and O'Dell (1988) examined attributes of computer based instruction, and attempted to affect certain attributes by regulating text density for print and screen display lessons. Results suggested that print had more advantages than the computer

FIGURE 4
Wrap-Around Text With One Quarter Inch White Space



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screen in achievement, completion time, and learning efficiency for a statistics lesson. Therefore, the present study is limited to the examination of print-based, computer-generated text .

METHOD

Subjects.

One hundred, thirty-two undergraduate students from an introductory computer literacy course at a major university in the Southwest, participated in the study. The elective course was a 400 level course which was offered to meet a General Studies numeracy requirement. Students were sophomores, juniors, and seniors who had little or no previous exposure to computers. The study was conducted at the beginning of the semester and all students in the course participated. Students had little or no prior knowledge about the topic presented in the study materials.

Materials.

Readings. Readings included approximately six pages of informative text about hypercard and desktop publishing. These materials were chosen because the topic was relevant to the subjects and because the reading level was geared for the general public as opposed to technical readers. The topic was suited to a novice audience with no prior knowledge about either hypercard or desktop publishing. The text was analyzed using the Flesch-Kincaid Readability formula and was found suitable for college students at the 11th and 13th grade levels.

Three sets of reading materials were used for this study. All included the same text and graphics arranged in single column format, but each set utilized a different text wrap respecting the graphic. The three sets included one with straight-framed graphics (see Figure 1, Run-Around Text), one with text tightly fitted around the graphics (see Figure 2, Wrap-Around Text), and one in which the graphic was placed directly over the text (see Figure 3, Transparent Text).

Although the graphics placement within these three sets of reading materials might not follow all of the elements of good design, it is important to know that the way in which they were developed is indicative of what practitioners will design. A sixth grade teacher who had a masters degree in the design and utilization of educational media, and who helped to instruct a desktop publishing course, was very much involved in the design of these reading materials. Therefore, any flaws in the materials design are potential problems that other teachers and trainers might exhibit as well.

Pretest and Posttest. To measure the students' comprehension of the reading material, a pretest and a posttest were developed from key concepts which the authors extracted from the readings. No test items were dependent upon the information contained in the graphics. The tests were developed and validated during a previous phase of the project, and were found to be reliable at the .76 level. The pretest and posttest were identical with one exception; the posttest contained an additional six-question attitude section. The attitude section included questions regarding the students' judgement of the difficulty of content, the degree to which graphics interfered with their comprehension and reading speed, their degree of interest in the subject, and their overall understanding of the material after reading it. These attitude questions were measured on a Likert-type scale and were not included in the posttest comprehension score.

Procedure.

All subjects were given a pretest to determine their knowledge of the subject prior to reading. There was no time limit and students were free to take the time they needed to complete the test. Next, the three sets of reading materials were randomly distributed to the students so that each student received one set of articles. Students were instructed to read through the text one time without hurrying. When subjects were finished reading, each of their reading times was recorded. Immediately following the reading, the subjects were given the posttest for comprehension. They were allowed as much time as they needed to complete the test.

RESULTS AND CONCLUSIONS

The design of the study was an analysis of variance. The independent variable was the text-graphic format (run-around, wrap-around, or transparent text) and the dependent measures included reading speed and gain in comprehension as measured by the difference between the pretest and posttest scores. The alpha level for significance was set at .05.

Table 1 shows the mean scores for the pretest, posttest, gain, and time elapsed for each of the treatment groups. Although the ANOVA showed no significant difference in either comprehension or speed among the three treatment groups, the table does show some patterns that may be worth noting. First, it appears that the wrap-around treatment group had a higher mean gain than the transparent treatment group, which in turn had a higher mean gain than the run-around treatment group. Second, it appears that the wrap-around treatment group also had the fastest reading speed, followed by the run-around group and then the transparent group. We can conclude that the wrap-around treatment group had the best comprehension and the fastest reading time, even though those results are not outstanding enough to be statistically significant.

TABLE 1
Mean Scores

	Pretest	Posttest	Gain	Time
Run-Around	13.85	45.47	31.62	13.74
Wrap-Around	13.55	51.91	38.36	12.59
Transparent	12.57	47.76	35.19	14.51

We might consider the possibility of interference in the scores of the transparent text group. Although the three text-wrap forms were randomly distributed, the transparent group started off with a mean pretest score that was a full point lower than the other two groups. There is no explanation for this occurrance. One might speculate that the transparent group took more time looking at the graphics than the other groups, although one student commented in a post study discussion that she was unaware of any graphics being there as she read, suggesting that she read right through the graphics. We venture to guess that the lower comprehension scores on for the run-around text group might be because the text is more difficult for the eye to follow due one of three possible reasons: 1) there are larger gaps of white space that the eye must jump across to continue reading, 2) there are variations in the amount of white space that the eye must jump across to continue reading, or 3) the text justification might interfere with reading continuity.

Irregular lines of text around a graphic and graphics placed over text did not confuse the readers in this study. The new enhancements currently available in desktop publishing software, particularly the wraparound features, were not found to inhibit reading.

Because a significant difference in both reading speed and comprehension was found between the run-around and wrap-around treatment groups in a prior study, we suggest replication of this study. Further, we suggest that subjects in each of the three treatment groups be quizzed about their recollection of the graphics to see if they actually look at the graphics as they read or if they concentrate on the text alone. Because graphics are used for different reasons, such as decoration versus information, it could be important to know whether the subjects actually look at the decorative graphics. It is possible that subjects' reading speed and comprehension with the three text-wrap configurations could vary dependent upon the type of graphic used.

Future studies should consider perceptual principles such as proximity, similarity, continuity, and closure. These four processes, by which the mind organizes meaning, depend on how physically close the objects are, how similar they are, whether there is a continuous line to guide the eye, and whether the minimal amount of information is present that is necessary to obtain meaning or closure. Reading speed and comprehension are directly affected by the way the mind organizes meaning from the placement of graphics and text.

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Title:

Effects of Different Loci of Instructional Control on Students' Metacognition and Cognition: Learner vs. Program Control

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Overview

This study is an investigation of the effects of different loci of instructional control on students' metacognition and cognition in a computer-assisted learning environment. The loci of instructional control compared in this study are learner and program control over instructional elements in a lesson. LOGO, a computer programming language, is the content area to be taught. Subjects are third-grade students.

This study is intended to provide valuable guidance for the design of educational software. Addressing conflicting issues regarding instructional design strategies may help maximize the potential of computers as educational media.

Need for Research

As sophisticated vehicles for instruction, computers can create highly motivating and dynamic learning environments (Feurzeig, 1988), and present a virtually unlimited range of options to instructional designers and individual learners (Burke, 1982; Gay, 1985). During the last few years, educational technology researchers have recognized the unique and divergent instructional capabilities of computers, and thus have responded by enthusiastically devoting efforts to the improvement of computer education. In such efforts, there has been a great emphasis on systematic methods for designing Computer-Assisted Instruction (CAI), and enhancing the quality of educational software.

The adoption of computers to educational settings has enabled interaction between learners and instructional materials. One of the issues currently attracting researchers' attention in the area of CAI design is the locus of instructional control: should instructional control be given to a learner (learner control), or to a program (program control)?

Most early CAI was designed on the basis of program control with little or no control given to a learner over instructional elements. One of the criticisms of such design is that it is based on the assumption that instructional designers are the best judges of when, where, how much and what kind of instruction is needed to teach certain knowledge or skills (Hannafin, 1984). Learner control, in contrast, is an instructional design strategy that provides a learner with freedom to make key decision(s) about her/his own learning rather than being locked into the elements predesigned by an instructor or instructional designer. Flexibility is the intended outcome of this strategy.

Nunan (1983) contended that knowledge is constructed in the process of learning, that a learner is an intentional agent, and that instructional designers should therefore seek alternative design strategies to reject the "technological philosophy of education" and the "common-sense structure of professionalized design" that have predominated in the area of instructional design. Instead of program control, I propose learner control as one of possible alternatives that place active learners at the center of learning.

In sum, in seeking systematic methods to enhance the quality of educational software, the nondeterministic approach of learner control to instructional design seriously challenges the traditional instructional design paradigm, program control, upon which most CAI has been built (Duchastel, 1986). However, the intuitively appealing assumptions and theoretical arguments regarding learner control have received little support from actual research (Steinberg, 1977; Carrier, 1984; Clark, 1984). The question of whether we need to assign control to a learner or to a program has frequently been asked, but is unresolved. Therefore, it remains as an empirical issue requiring research attention.

Importance of Learner Control in Comparison with Program Control

Advocates of learner controlled instruction have discussed its various advantages. This study will focus on two of the possible benefits of learner control: 1) positive approach to individual differences, and 2) enhancement of metacognition and cognition.

One of the most important benefits of learner control is its positive interaction with individual differences. It is often argued that the unique advantage of CAI is its ability to adapt to the needs of individual students. Theorists and researchers have enthusiastically attempted to design individualized instruction through CAI that can accommodate various types of individuals in educational practice. However, while most people agree with the premise that individual learners are different in ways that influence performance in instruction, there seems to be little agreement about the way in which individualization of instruction should be achieved (Carrier, 1984; Gray, 1987). On this point, research on learner control has begun with the recognition that no one instructional treatment can be best for every learner (Kinzie et al., 1987).

Another important advantage of learner control is the enhancement of metacognition and cognition through its dynamic learning processes. Unlike program controlled instruction, which aims to improve only products of learning, learner controlled instruction emphasizes processes as well as products of learning. Cognitive psychologists object to the prescriptive characteristics of traditional instructional design under program control, whereby instruction acts upon a learner, as opposed to a learner taking responsibility for her/his own learning (Bonner, 1988).

According to Flavell (1979, 1987), metacognition refers to the active monitoring and consequent self-regulation of one's own cognitive processes, and orchestration of these processes in the service of some concrete goals or objectives. Under learner control, individual learners are in a position to systematically analyze the nature of a task; to monitor and analyze their own understanding of the given task; to select activities that can be performed to accomplish the task; and to actively decide levels or amounts of instruction needed to extend the present knowledge state, while continuously monitoring their own cognitive processes and performances. By being aware of control options and deliberately making decisions about the use of the options under learner control, learners can continuously evaluate their progress towards a given objective and attempt to develop effective learning strategies to achieve this objective. As a result, they can more thoroughly integrate new learning materials within their existing knowledge schema, and enhance metacognitive knowledge and experiences in a more effective way than they would with program control.

In spite of the importance of metacognitive enhancement, instructional designers have not shown much concern for metacognitive development of learners, especially as integrated with subject matter, and this may impose limitations on further progress in understanding learning (Bonner, 1988). Metacognitive enhancement should be considered within educational research and practice as a desired outcome of instructional interventions, along with cognitive enhancement such as achievement. Nickerson et al. (1985) contended that although content specific knowledge is necessary for the best performance, it is not sufficient to guarantee such performance. In fact, as Perkins and Salomon (1989) have asserted, efforts need to be devoted to combining the teaching of subject-matter content and of thinking, as one of the exciting domains of the next decade of educational research and innovation. Learner control is one of the strategies that attempt to combine those two areas.

In short, in carrying out this study, the following theoretical propositions are made: by providing students with control options over a key instructional element and by emphasizing processes as well as products of learning, learner control will accommodate individual differences and influence metacognitive as well as cognitive enhancement in a more effective way than will program control.

PURPOSE

The purpose of the study is to examine the effects of two different loci of instructional control on metacognitive and cognitive enhancement and individual differences, in a computer-assisted instructional environment. There are three major research goals. The first is to compare the effects of learner control with those of program control on students' metacognition, knowledge acquisition and knowledge application, with total subjects. The second goal is to extend the comparison between learner control and program control by classifying the total learner control group into two groups, according to the effectiveness of students' uses of control options (active learner control group and passive learner control group), and making comparisons between each of the two learner control groups and the program control group. The third goal is to investigate whether results of comparisons between learner control and program control change in relation to students' different levels of prior knowledge of mathematical concepts related to those in logo (prior background knowledge). The following figures summarize these three topics:

1) Topic 1 - with total learner control group

X1	O1	O2	O3
X2	O1	O2	O3

X1 - learner control treatment
X2 - program control treatment

O1 - test on knowledge acquisition
O2 - test on knowledge application
O3 - interview on metacognition

2) Topic 2 - with active or passive learner control group

X1	X11	O1	O2	O3
	X12	O1	O2	O3
X2		O1	O2	O3

X1 - learner control treatment with total group
    X11 - learner control with active group
    X12 - learner control with passive group
X2 - program control treatment with total group

O1 - test on knowledge acquisition
O2 - test on knowledge application
O3 - interview on metacognition

3) Topic 3- with high or low prior background knowledge group

A	X1	O1	O2	O3
	X2	O1	O2	O3

B	X1	O1	O2	O3
	X2	O1	O2	O3

A - high prior background knowledge group
B - low prior background knowledge group

X1 - learner control treatment
X2 - program control treatment

O1 - test on knowledge acquisition
O2 - test on knowledge application
O3 - interview on metacognition

METHOD

Subjects

The study was conducted with a class of 24 third graders enrolled in an urban elementary school in Wisconsin during the fall of 1989. None of the students had previously learned about logo.

Materials

Students in both learner and program control treatment groups were introduced to basic logo commands with definitions, rules, examples and practice. In practice, students were challenged to hit a given target or aim towards it by changing the turtle's position or heading with the learned command. Two parallel versions of programs were used: one for the learner control group and the other for the program control group. Both versions were delivered by Apple IIe computers along with the posttests. The resulting instructional units for both learner control and program control underwent expert review.

Throughout the instruction, students were able to: 1) identify the screen turtle and the properties of the turtle, i.e. position and heading; 2) recall and use the logo commands for moves that change the position of the turtle in an immediate mode, i.e. FORWARD (FD) and BACK (BK); 3) recall and use the logo commands for turns that change the heading of the turtle in an immediate mode, i.e. LEFT (LT) and RIGHT (RT); 4) predict outcomes of commands and debug commands; and 5) (under learner control) analyze the following: how well do I understand the given command? What don't I know about it? What do I need to review to change the present state of my knowledge?

Treatment

Two types of treatments were employed in this study on the basis of each locus of instructional control: learner control and program control. The former consisted of internally controlled CAI in which students were free to decide whether and how often they needed to review some of the instructional components relevant to a practice item, or to skip the review. In contrast, the latter consisted of externally controlled CAI: all control in the lessons was regulated by the program on the basis of predesigned rules, so that students had no control over instructional components except the instructional pace -- they could advance through the instruction when they were ready.

program control: In the tutorial portion of each lesson, students learned the definition, the rule and four examples of a logo command. Then, four practice items were presented. When a correct response was made, students received positive feedback and moved to the next practice item. When an incorrect response was made, the program provided students with negative feedback and automatically branched them to the review of the definition, the rule and an example of the command under consideration. The review of instruction for practice was presented only after the first wrong answer. Under program control, when students exhibited a lack of understanding of a given logo command, they were guided to review instructional elements relevant to the command. Such repetitive instruction may reinforce students' understanding of a given topic.

After the review, students had a second opportunity to respond to the practice item. If the answer was still wrong, personalized feedback was presented to show the correct answer, and the next practice item was presented. At the end of the practice session, a total score was displayed.

learner control: The differences between learner control and program control were made only in the presentation of the question for self-estimates of understanding on a given command and in the way in which review was presented after a wrong answer. After the tutorial portion of a lesson, as a part of the treatment, students were asked to rate their understanding of the given command on a four-item Likert scale (1 for 'not at all' and 4 for 'very well'), and to solve four practice items. When an incorrect response was given to a practice item, they were told that their answer was wrong and were continuously advised to think about what they did not clearly understand about the command learned and what they should review. Then, students were allowed to review the instruction for practice, the definition and the rule of the command, or an example of the command, as many times as they wanted to, or to skip the review. Every time they used a review option, a summary of their performance in practice and uses of control options was provided. When students decided not to review any more, a question was presented to confirm if they understood the command well enough to try the practice item again. Then, with confirmation, they had an opportunity to solve the same practice item a second time. When the practice session was completed, a total score was reported along with the students' self-estimates of their understanding of the given command.

In addition, the following factors were integrated into the design of learner controlled instruction, as recommended by researchers and theorists. First, control options were clearly labeled to help students use control options effectively (Reigeluth and Stein, 1983). Second, immediate feedback, continuous advice on students' progress and summaries of their uses of control options were presented to help students make informed decisions about their own learning (Hannafin, 1984; Kinzie, 1988; Lepper, 1985; Lepper & Malone, 1987; Markman, 1977; Merrill, 1984; Tennyson, 1980, 1981; Tennyson & Buttrey, 1980; Waldrop, 1984). Third, students were required to solve a certain number of practice items to assure that they did not bypass important instructional components (Kinzie, 1988; Steinberg, 1977; Waldrop, 1984). Fourth, prior to the instruction, there was a pretraining period to help students become familiar with the novel learning system with control options, perform conscious cognitive information processing, and acquire declarative (knowing what), procedural (knowing how) and conditional (knowing why and when) knowledge involved in building their own learning strategies (Campbell, 1964; Gay, 1986; Hannafin, 1984; Holmes et al., 1985; Kinzie, 1988; Merrill, 1975, 1984; Schimmitt & Newby, 1985; Steinberg, 1977; Wydra, 1980).

Procedure

Prior to the experiment, on the basis of a mean score on a test on mathematical concepts which are specifically related to logo (e.g. distance and direction), students were identified as belonging to either a high or low prior background knowledge group. Then, in each group, students were randomly assigned to either the learner control or the program control treatment condition. To motivate students, they were informed that although scores on tests would not affect their class grades, their teacher would take a look at their scores. Such information should be presented to stimulate an actual classroom-like incentive that is missing in most learner control studies (Tennyson, 1980; Tennyson & Buttrey, 1980).

The study was conducted over a three-week period with three sessions per week. Each session took about 40 minutes. Before instruction began, there was a pretraining section aimed at help students to become familiar with computers, instructional systems and control options, and to understand the declarative, procedural and conditional knowledge involved in using control options. Then, lessons on logo commands were presented. In each session of instruction, those who finished a lesson earlier than the others were asked to remain in the lab and spend the rest of the session with a paper-and-pencil task on a maze. Upon completion of all instruction, posttests on knowledge acquisition and application and an interview on metacognition were conducted.

Dependent Variables

1) Interview on Metacognition: To serve the major purpose of this study, an adaptation of the Metacomponential Interview developed by Clements and Nastasi (1988) was employed. This interview instrument was developed to assess children's specific executive levels of metacognitive functioning in a mediated situation with aid through a series of prescribed prompts for mediational purposes. Although five metacomponents of the seven proposed by Sternberg (1985) are included in this instrument, in relation to

the learning experience gained through this study, only one metacomponent, monitoring solution processes, was employed in assessing metacognitive effects.

Four questions were presented, with five prompts per question (appendix 3). The number of prompts required for the solution of each question was summed and transformed so that a higher score refers to fewer prompts required and better performance. Further, the transformed scores were summed again over question items. In addition, as Clement and Nastasi directed, the following measures were taken for each question: 1) the number of prompts needed to demonstrate the identification of the fact that something was wrong in presented information and induction (utilization); and 2) the number of prompts needed to answer correctly (correctness). The Cronbach's α reliability values obtained were .53 for utilization and .60 for correctness. The entire interview process was recorded for later analysis and used to test inter-rater agreement in scoring. The correlation values for inter-rater agreement were .87 for utilization and .92 for correctness.

2) Test on Knowledge Acquisition: A 16-item posttest was administered. In the test, items similar to the practice ones embedded in the instruction were presented to explore students' knowledge acquisition. The number of test items on each logo command was equally balanced across all the commands taught throughout the instruction. The Cronbach's α reliability value among the test items for each command was .86.

3) Test on Knowledge Application: Given the length of each side of a square on the screen, students were asked to draw a square by changing the turtle move and turn. In order to avoid any possible confounding effects due to the use of multi-media, both tests on knowledge acquisition and application were delivered by computers along with instruction, and students worked individually with assigned computers.

HYPOTHESES

To serve the purpose of this study, the following hypotheses were examined:

1) The learner control group will show significantly higher scores than the program control group in the tests on metacognition, knowledge acquisition and knowledge application.

2) Significant differences between learner control and program control will be more apparent when the active learner control group is compared with the

program control group than when the passive learner control group is compared with the program control group.

3) For both the group with high prior background knowledge and the group with low prior background knowledge, the learner control group will demonstrate higher scores than the program control group in the tests on metacognition, knowledge acquisition and knowledge application.

DATA ANALYSIS AND RESULTS

Analysis of Variance (ANOVA) methods were utilized in examining the effects of two different loci of instructional control on metacognition (monitoring solution processes), knowledge acquisition and knowledge application.

Total Learner Control vs. Program Control

First, the performance of all students under learner control in the interview on metacognition (utilization and correctness of monitoring) and the tests on knowledge acquisition and application was compared with that of all students under program control, on the basis of an ANOVA. Significant differences were found in both utilization of monitoring and correctness of monitoring (Table 3). Regarding the metacognitive effects due to the treatment, students under learner control showed significantly higher scores in both the utilization and correctness of monitoring than students under program control. On knowledge acquisition and application, students under learner control showed higher scores than those under program control, but no significant difference between the two treatments was found.

Insert Table 3, Figure 3.1 and Figure 3.2 about here

Active or Passive Learner Control vs. Program Control

Then, to permit further investigation of the comparative effects of the two treatment conditions, students under learner control were classified into two groups according to the effectiveness of their usage of control options. An ANOVA was conducted to compare each of the two learner control groups (active and passive) with the total program control group. Effectiveness was evaluated on the basis of the accuracy of the self-estimates of understanding of the logo command taught and the appropriateness of the uses of control options; the relation between one's rate of understanding on a four-item Likert scale and her/his subsequent performance in practice, and the relation between the number of reviews and the number of wrong answers in practice (appendix 2).

First, to compare the active learner control group with the program control group, an ANOVA was conducted on the four dependent variables (table 4). In contrast with the results of the comparison between the total learner control and the program control treatment groups, a significant difference was found in knowledge acquisition and more significant differences were found in utilization and correctness of monitoring. However, no significant difference was found in knowledge application.

Insert Table 4, Figure 4.1 and Figure 4.2 about here

Second, to compare the passive learner control group with the program control group, an ANOVA method was also utilized with the four dependent variables (table 5). No significant difference was found in any of the dependent variables between the two treatment groups.

Insert Table 5, Figure 5.1 and Figure 5.2 about here

Learner Control vs. Program Control: With High or Low Prior Background Knowledge Groups

In addition, in order to explore the effects of two different loci of instructional control on individual differences (different levels of prior background knowledge), students were classified into two groups (high or low prior background knowledge groups) on the basis of a test assessing knowledge of mathematical concepts related to logo. For each of the two groups, an ANOVA was conducted to compare the effects of learner control on metacognition, knowledge acquisition and knowledge application with those of program control. Further, an ANOVA method was also used to compare the high prior background knowledge group with the low prior background knowledge group on the accuracy of students' self-estimates of understanding of a given logo command, appropriateness of the uses of control options and effectiveness of the uses of control options.

First, with the students who demonstrated high prior knowledge of mathematical concepts related to

logo, the comparison between the learner control treatment and the program control treatment was made by conducting an ANOVA on the dependent variables (table 6). Significant differences between the two treatment groups were identified, in favor of learner control, in all the four dependent variables: utilization of monitoring, correctness of monitoring, knowledge acquisition and knowledge application.

Insert Table 6, Figure 6.1 and Figure 6.2 about here

Second, with those who demonstrated low levels of prior background knowledge, the comparison between the learner control and the program control treatments was made on the basis of an ANOVA on the dependent variables (table 7). Although the overall performance of the learner control group was better than that of the program control group, no significant difference was found in any of the variables between the two treatment groups.

Insert Table 7, Figure 7.1 and Figure 7.2 about here

Additionally, an ANOVA on the accuracy of self-estimates of understanding, the appropriateness of the uses of control options and the effectiveness of the uses of control options was conducted to investigate any differences between the high and low prior background knowledge groups (table 8). Significant differences were found in all those variables between the two groups, in favor of the group with high prior background knowledge.

Insert Table 8, Figure 8.1 and Figure 8.2 about here

DISCUSSION

In this study, pretraining was provided to both treatment groups in order to help students become familiar with the given learning systems. Supported by this pretraining along with the presentation of clearly labeled control options and a basic requirement to solve a certain number of practice items, students under learner control were asked to estimate their own understanding of the given logo command and make "informed decisions" in using learner control on the basis of immediate feedback, continuous advice and summaries of their performance and uses of control options.

When these supportive factors were integrated into the design of a learner control study, learner control seemed to foster students' metacognitive as well as cognitive abilities in a more effective way than would program control, regardless of different levels of prior background knowledge of a related subject. The overall performance of the total students under learner control in monitoring solution processes and in recalling and applying learned knowledge was higher than that under program control. In particular, significant differences were found in the assessment of metacognition in favor of learner control. Under learner control, one becomes responsible for her/his own learning, practices conscious reflection on her/his cognitive abilities, task demands and learning strategies, and learns how to manage her/his own thinking processes and learning activities. Thus, one can be led to enhance her/his metacognitive abilities to perform and behave strategically. These learned strategies may be those that transfer to other contexts and facilitate learning activities effectively and efficiently.

Unlike the effects on metacognition, the difference between the learner and program control treatments in the effects on cognition (knowledge acquisition and application) was not statistically significant. However, when an extended comparison between the two treatments was made with the active learner control group that exhibited effective uses of control options, a significant difference was found in knowledge acquisition in favor of learner control. It seems that only when students under learner control can use given control options effectively by making accurate self-estimates of understanding and appropriate uses of control, they can obtain significantly more benefit in enhancing cognition as well as metacognition than students under program control. Although in this study students under learner control demonstrated better performance in the assessment of cognition with aids from supportive factors built into the design of instruction, they still showed different levels of effectiveness in using control options. Further investigation is needed of such supportive factors that can help students use control effectively.

In addition, concerning students' prior knowledge of mathematical concepts related to those in logo, in the learner control treatment group, students who exhibited relatively high levels of prior background knowledge were significantly more capable of using the given control options than were those with low prior background knowledge. Students with low prior background knowledge tended to estimate their own understanding inaccurately and to review too little. Further, among the students with high prior background knowledge, different effects between learner control and program control were significantly apparent in favor of learner control, in the assessment of metacognition and cognition. However, only slight differences between the two treatments were found among the students with low prior background knowledge, in favor of learner control.

These findings about individual differences in prior background knowledge indicate that students' prior knowledge of a subject matter relevant to the one learned is important in helping them to understand the underlying structure of a given instruction, to develop effective learning strategies and thus to enhance metacognitive and cognitive abilities. As Snow (1980) contended, learner controlled instruction may not overcome the fact that "individual characteristics not under control of the individual will determine to a significant extent what and how much that individual will learn in a given instructional setting" (p.1). Snow argued that research on learner control generally has not proved optimal performance because it is not known which types of learners should be granted control and under which conditions.

In this study, in attempting to find ways to overcome problems that students with low prior background knowledge may have under learner control, supportive factors (pretraining, provision of clearly labeled options and basic requirements, and presentation of feedback, advice and summaries) were integrated into the design of instruction. With these supports, students under learner control exhibited better performance than that of those under program control regardless of their different levels of prior background knowledge. This finding is contradictory to that of some previous research on learner control (Goetzfried and Hannafin, 1985; Hannafin, 1984; Kinzie, 1988; Krendle and Lieberman, 1988; Steinberg, 1977; Tennyson, 1981) which supported the Achievement-Treatment Interaction theory (Tobias, 1976); for students with a low level of prior knowledge, learner control is less effective than program control and for those with a high level of prior knowledge, learner control is more effective than (or comparable to) program control.

It seems that learner control can convey the role of providing opportunities to improve metacognitive monitoring abilities, while attempting to teach knowledge of specific subject matter content in a more effective way than can program control, regardless of learners' different levels of prior knowledge of a relevant subject matter. However, it should be noted that this study has been conducted with a relatively limited application of control in introductory instruction, and for a short time period. Considering the potentially rich and unique learning environment and experiences that learner control can provide, more research efforts should be devoted to developing instructional models of learner control from which all students can benefit in enhancing metacognitive as well as cognitive abilities.

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APPENDIX 1

Table 1
Total Possible Scores for Metacognition, Knowledge Acquisition and Knowledge Application

variables	total possible score
monitoring: utilization	24
monitoring: correctness	24
knowledge acquisition	32
knowledge application	70

Table 2
Means and Standard Deviations for Metacognition, Knowledge Acquisition and Knowledge Application

	total	lc			pc	low	high
variables		all	active	passive			
monitoring: utilization	10.96 (3.80)	12.42 (4.12)	12.67 (3.20)	12.17 (5.19)	9.50 (2.94)	10.33 (4.31)	11.58 (3.29)
monitoring: correctness	7.21 (4.25)	8.83 (4.45)	10.33 (2.58)	7.33 (5.61)	5.58 (3.50)	6.00 (4.65)	8.42 (3.60)
knowledge acquisition	19.04 (6.92)	21.33 (7.52)	23.33 (7.69)	19.33 (7.47)	16.75 (5.67)	16.50 (6.10)	21.58 (7.00)
knowledge application	46.04 (17.75)	50.42 (17.51)	55.00 (15.49)	45.83 (19.60)	41.67 (17.62)	37.50 (18.28)	54.58 (12.87)

Note: Standard Deviations are presented in parentheses.
lc = learner control treatment group
all = total subjects under learner control
active = the learner control group that showed effective uses of control options
passive = the learner control group that showed ineffective uses of control options
pc = program control treatment group

Table 3
TOTAL LEARNER CONTROL VS. PROGRAM CONTROL:
1) Means and Standard Deviations for Metacognition, Knowledge Acquisition and Knowledge Application
2) F Ratios and F Probabilities between the Treatment Groups

variables	control condition	mean	standard deviation	F Ratio	F Prob.
monitoring: utilization	lc	12.42	4.12	3.9832	.0585 *
	pc	9.50	2.94		
monitoring: correctness	lc	8.83	4.45	3.9544	.0593 *
	pc	5.58	3.50		
knowledge acquisition	lc	21.3	7.52	2.8384	.1062
	pc	16.75	5.67		
knowledge, application	lc	50.42	17.51	1.4885	.2354
	pc	41.67	17.62		

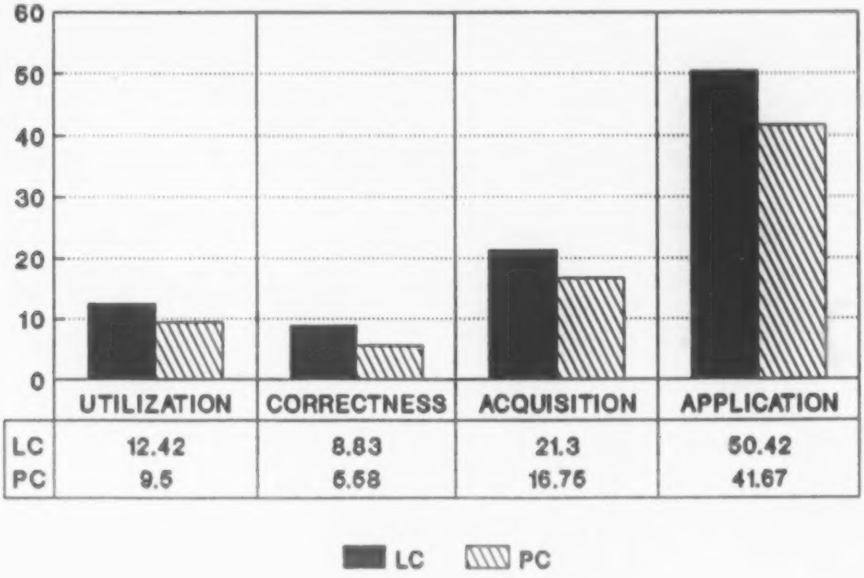
* p<.10

Note: lc = learner control treatment group
pc = program control treatment group

Figure 3.1

LEARNER CONTROL VS. PROGRAM CONTROL

WITH TOTAL LEARNER CONTROL



	UTILIZATION	CORRECTNESS	ACQUISITION	APPLICATION
LC	12.42	8.83	21.3	50.42
PC	9.5	5.58	16.75	41.67

Figure 3.2

LEARNER CONTROL VS. PROGRAM CONTROL

WITH TOTAL LEARNER CONTROL

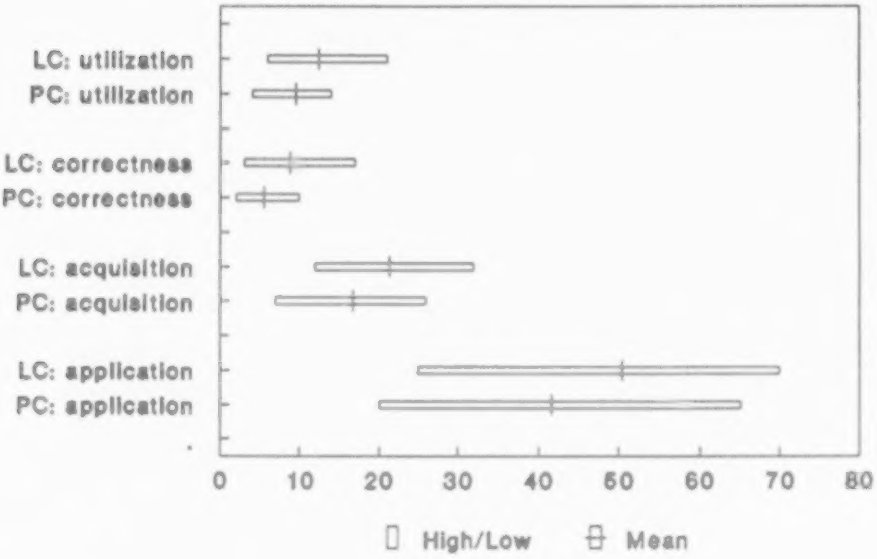


Table 4
ACTIVE LEARNER CONTROL VS. PROGRAM CONTROL:
1) Means and Standard Deviations for Metacognition, Knowledge Acquisition and Knowledge Application
2) F Ratios and F Probabilities between the Treatment Groups

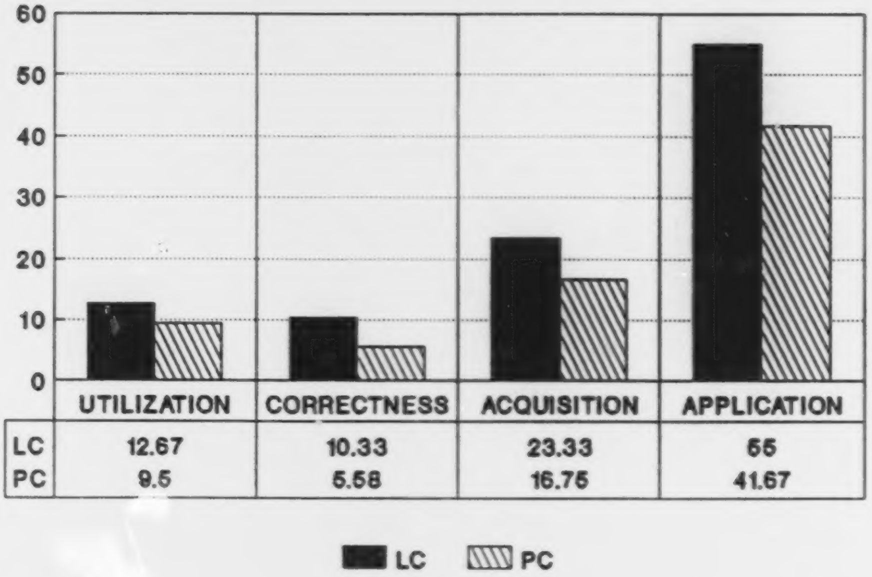
variables	control condition	mean	standard deviation	F Ratio	F Prob.
monitoring:	lc	12.67	3.20	4.3857	.0525 *
utilization	pc	9.50	3.94		
monitoring	lc	10.33	2.58	8.5800	.0098 **
correctness	pc	5.58	3.50		
knowledge	lc	23.33	7.69	4.2701	.0554 *
acquisition	pc	16.75	5.67		
knowledge	lc	55.00	15.49	2.4645	.1360
application	pc	41.67	17.62		

* p<.10
** p<.01

Note: lc = learner control treatment group
pc = program control treatment group

Figure 4.1

LEARNER CONTROL VS. PROGRAM CONTROL
WITH ACTIVE LEARNER CONTROL



	UTILIZATION	CORRECTNESS	ACQUISITION	APPLICATION
LC	12.67	10.33	23.33	55
PC	9.5	5.58	16.75	41.67

Figure 4.2

LEARNER CONTROL VS. PROGRAM CONTROL
WITH ACTIVE LEARNER CONTROL

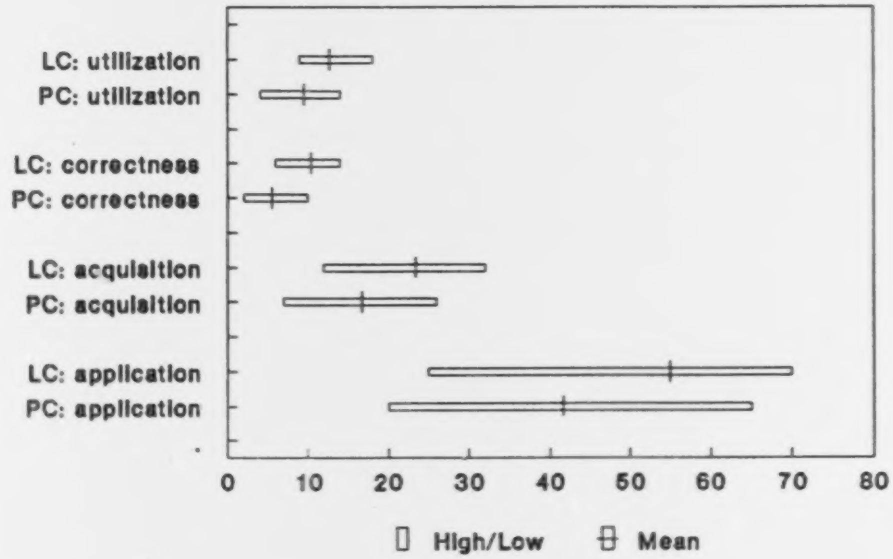
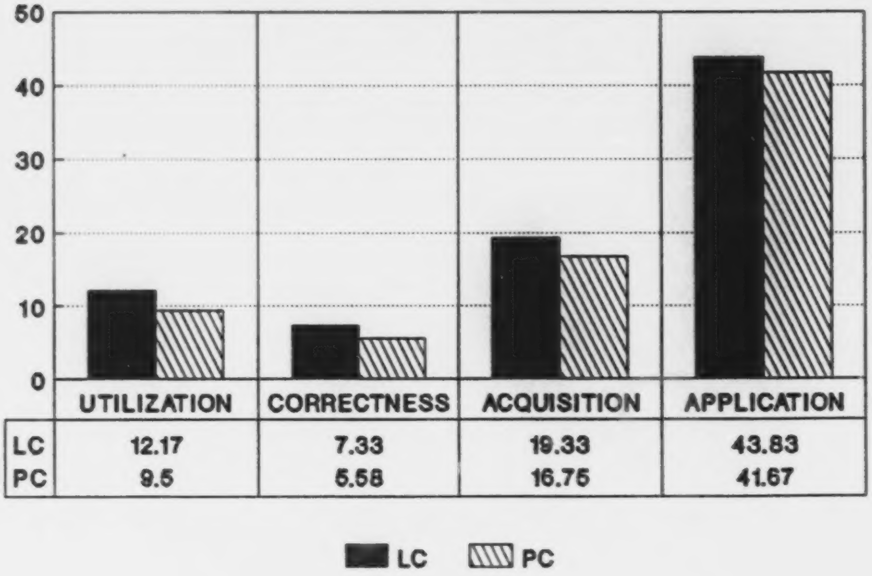


Table 5
PASSIVE LEARNER CONTROL VS. PROGRAM CONTROL:
1) Means and Standard Deviations for Metacognition, Knowledge Acquisition and Knowledge Application
2) F Ratios and F Probabilities between the treatment groups

variables	control condition	mean	standard deviation	F Ratio	F Prob.
monitoring: utilization	lc	12.17	5.19	1.9802	.1785
	pc	9.50	2.94		
monitoring correctness	lc	7.33	5.61	.6707	.4249
	pc	5.58	3.50		
knowledge acquisition	lc	19.33	7.47	.6741	.4237
	pc	16.75	5.67		
knowledge application	lc	43.83	19.60	.2082	.6543
	pc	41.67	17.62		

Note: lc = learner control treatment group
pc = program control treatment group

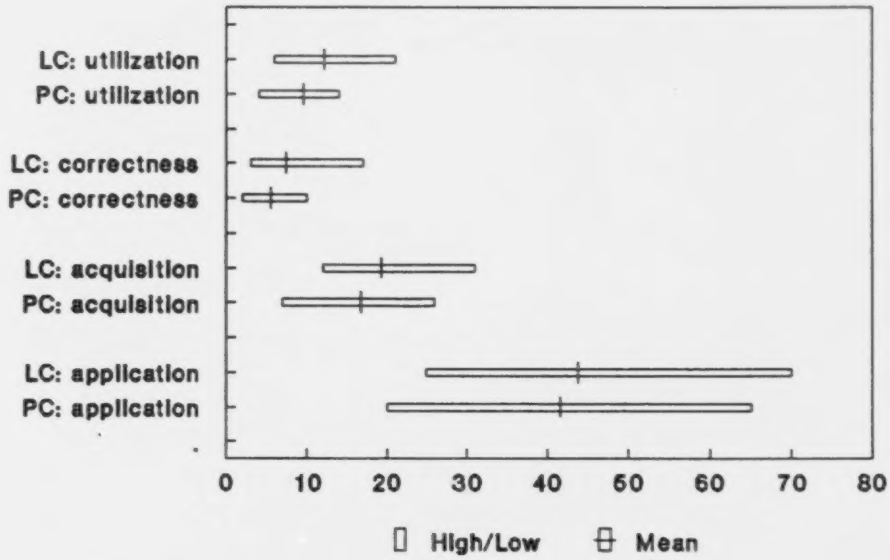
Figure 5.1



LEARNER CONTROL VS. PROGRAM CONTROL
WITH PASSIVE LEARNER CONTROL

	UTILIZATION	CORRECTNESS	ACQUISITION	APPLICATION
LC	12.17	7.33	19.33	43.83
PC	9.5	5.58	16.75	41.67

Figure 5.2



LEARNER CONTROL VS. PROGRAM CONTROL
WITH PASSIVE LEARNER CONTROL

Table 6
HIGH PRIOR Background knowledge GROUP
LEARNER CONTROL VS. PROGRAM CONTROL:
1) Means and Standard Deviations for Metacognition, Knowledge Acquisition and Knowledge Application
2) F Ratios and F Probabilities between the Treatment Groups

variable	control condition	mean	standard deviation	F Ratio	F Prob.
monitoring: utilization	lc	13.17	2.93	3.3865	.0956 *
	pc	10.00	3.03		
monitoring: correctness	lc	10.33	2.58	4.4604	.0608 *
	pc	6.50	3.62		
knowledge acquisition	lc	25.50	5.32	5.1879	.0460 **
	pc	17.67	6.53		
knowledge application	lc	60.83	4.92	3.4615	.0924 *
	pc	48.33	15.71		

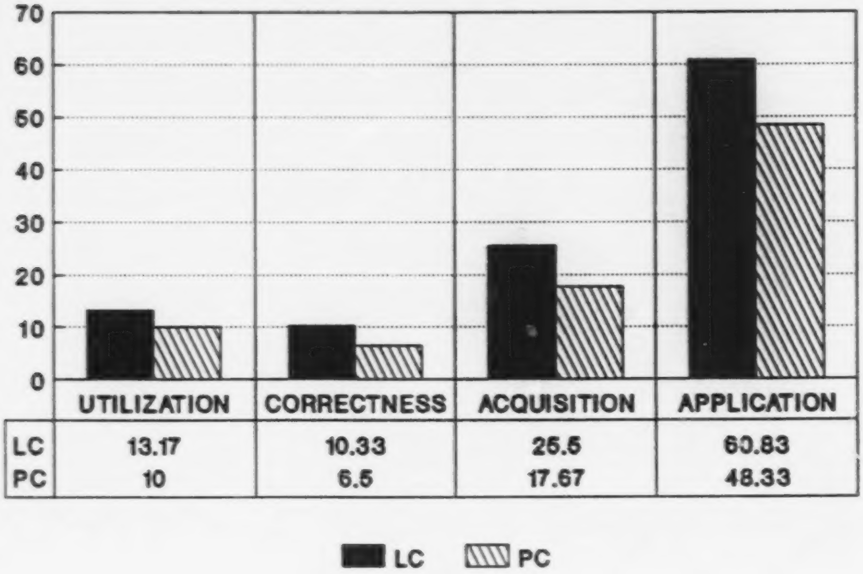
* p<.10
** P<.05

Note: lc = learner control treatment group
pc = program control treatment group

Figure 6.1

LEARNER CONTROL VS. PROGRAM CONTROL

HIGH PRIOR BACKGROUND KNOWLEDGE GROUP



	UTILIZATION	CORRECTNESS	ACQUISITION	APPLICATION
LC	13.17	10.33	25.5	60.83
PC	10	6.5	17.67	48.33

Figure 6.2

LEARNER CONTROL VS. PROGRAM CONTROL

HIGH PRIOR BACKGROUND KNOWLEDGE GROUP

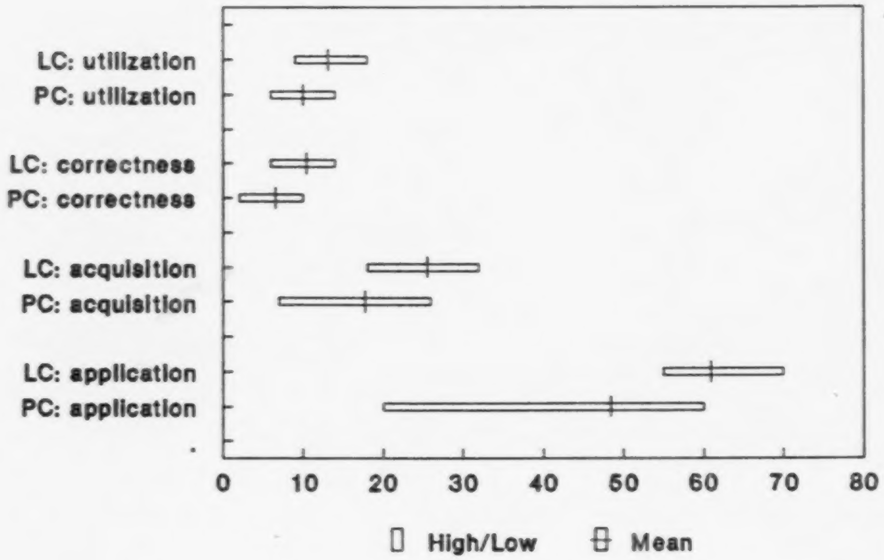
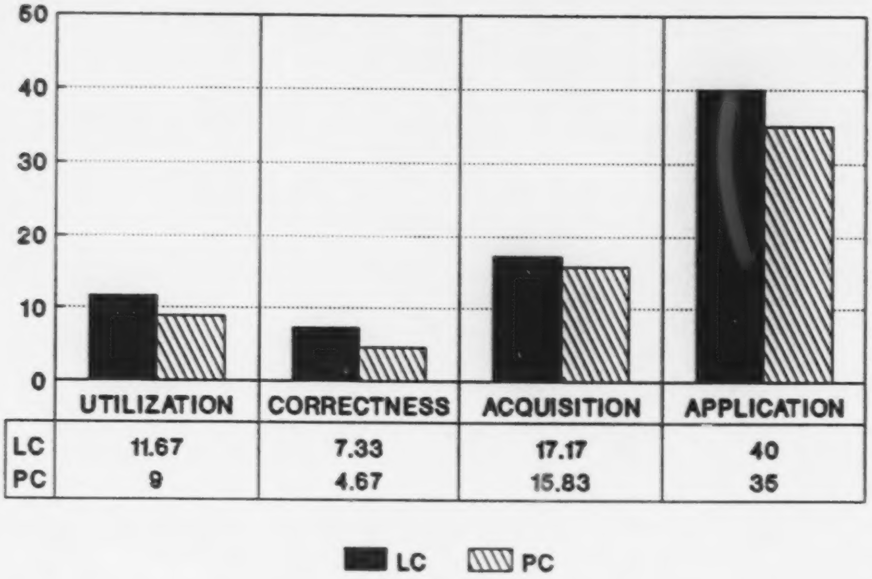


Table 7
LOW PRIOR Background knowledge GROUP
LEARNER CONTROL VS. PROGRAM CONTROL:
1) Means and Standard Deviations for Metacognition, Knowledge Acquisition and Knowledge Application
2) F Ratios and F Probabilities between the Treatment Groups

variables	control condition	mean	standard deviation	F Ratio	F Prob.
monitoring: utilization	lc	11.67	5.24	1.1636	.3060
	pc	9.00	5.24		
monitoring: correctness	lc	7.33	5.61	.9846	.3445
	pc	4.67	3.44		
knowledge acquisition	lc	17.17	7.39	.1321	.7238
	pc	15.83	5.12		
knowledge application	lc	40.00	19.75	.2083	.6478
	pc	35.00	18.17		

Note: lc = learner control treatment group
pc = program control treatment group

Figure 7.1
LEARNER CONTROL VS. PROGRAM CONTROL
LOW PRIOR BACKGROUND KNOWLEDGE GROUP



	UTILIZATION	CORRECTNESS	ACQUISITION	APPLICATION
LC	11.67	7.33	17.17	40
PC	9	4.67	15.83	35

Figure 7.2
LEARNER CONTROL VS. PROGRAM CONTROL
LOW PRIOR BACKGROUND KNOWLEDGE GROUP

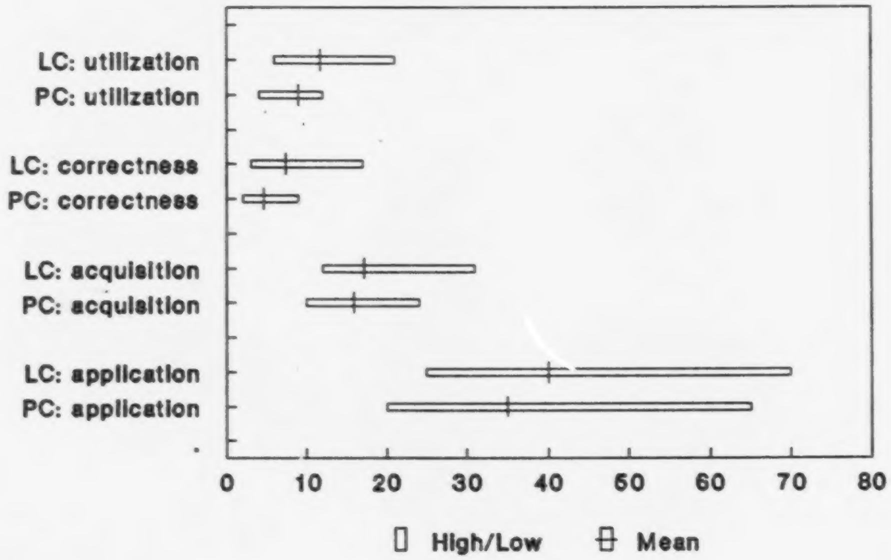


Table 8

HIGH VS. LOW PRIOR Background knowledge GROUPS

1) Means and Standard Deviations for Accuracy, Appropriateness and Effectiveness under Learner Control

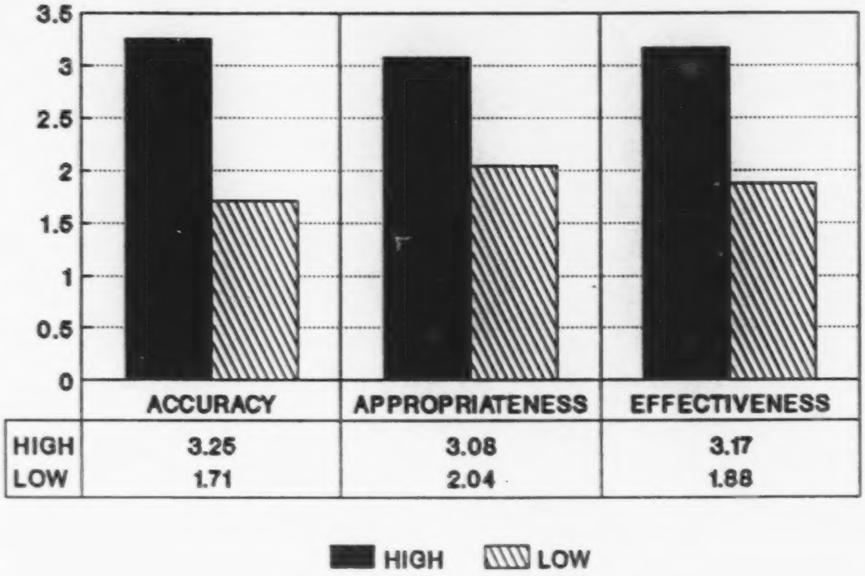
2) F Ratios and F Probabilities between the Groups

variables	control condition	mean	standard deviation	F Ratio	F Prob.
accuracy	high	3.25	.45	37.0000	.0001 ***
	low	1.71	.45		
appropriateness	high	3.08	.77	7.8715	.0186 *
	low	2.04	.49		
effectiveness	high	3.17	.58	18.9173	.0014 **
	low	1.88	.44		

* p<.05
** p<.01
*** p<.001

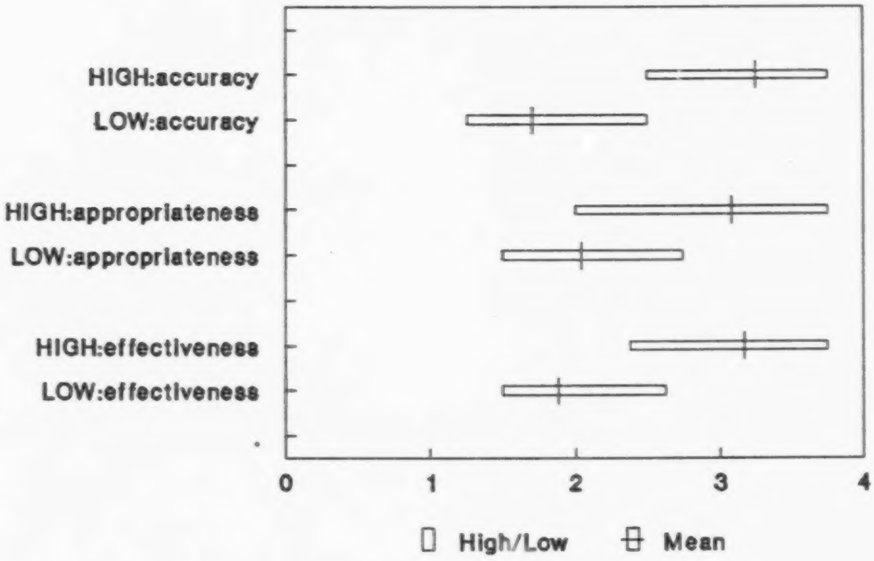
Note: high = high prior background knowledge group
low = low prior background knowledge group

Figure 8.1
HIGH VS. LOW PRIOR BACKGROUND KNOWLEDGE
ACCURACY, APPROPRIATENESS, EFFECTIVENESS



	ACCURACY	APPROPRIATENESS	EFFECTIVENESS
HIGH	3.25	3.08	3.17
LOW	1.71	2.04	1.88

Figure 8.2
HIGH VS. LOW PRIOR BACKGROUND KNOWLEDGE
ACCURACY, APPROPRIATENESS, EFFECTIVENESS



APPENDIX 2

ACCURACY OF SELF-ESTIMATES OF UNDERSTANDING

If SELF-EST="NOT AT ALL" & WRNO= 7 or 8, then ACCUR= 4.
If SELF-EST="NOT AT ALL" & WRNO= 5 or 6, then ACCUR= 3.
If SELF-EST="NOT AT ALL" & WRNO= 3 or 4, then ACCUR= 2.
If SELF-EST="NOT AT ALL" & WRNO= 1 or 2, then ACCUR= 1.
If SELF-EST="NOT AT ALL" & WRNO= 0, then ACCUR= 0.

If SELF-EST="A LITTLE" & WRNO= 7 or 8, then ACCUR= 2.
If SELF-EST="A LITTLE" & WRNO= 5 or 6, then ACCUR= 4.
If SELF-EST="A LITTLE" & WRNO= 3 or 4, then ACCUR= 3.
If SELF-EST="A LITTLE" & WRNO= 1 or 2, then ACCUR= 1.
If SELF-EST="A LITTLE" & WRNO= 0, then ACCUR= 0.

If SELF-EST="WELL" & WRNO= 7 or 8, then ACCUR= 0.
If SELF-EST="WELL" & WRNO= 5 or 6, then ACCUR= 1.
If SELF-EST="WELL" & WRNO= 3 or 4, then ACCUR= 4.
If SELF-EST="WELL" & WRNO= 1 or 2, then ACCUR= 3.
If SELF-EST="WELL" & WRNO= 0, then ACCUR= 2.

If SELF-EST="VERY WELL" & WRNO= 7 or 8, then ACCUR= 0.
If SELF-EST="VERY WELL" & WRNO= 5 or 6, then ACCUR= 1.
If SELF-EST="VERY WELL" & WRNO= 3 or 4, then ACCUR= 2.
If SELF-EST="VERY WELL" & WRNO= 1 or 2, then ACCUR= 3.
If SELF-EST="VERY WELL" & WRNO= 0, then ACCUR= 4.

SELF-EST: SELF-ESTIMATES OF ONE'S OWN UNDERSTANDING

WRNO: THE NUMBER OF WRONG ANSWERS IN A LESSON
(RANGE: 0 TO 8)

ACCUR: ACCURACY OF SELF-ESTIMATES OF UNDERSTANDING

APPROPRIATENESS OF THE USAGE OF CONTROL OPTIONS

If REVIEWNO - WRNO >= 0, then APPRO = 4.

If REVIEWNO - WRNO = -1 or -2, then APPRO = 3.

If REVIEWNO - WRNO = -3 or -4, then APPRO = 2.

If REVIEWNO - WRNO = -5 or -6, then APPRO = 1.

If REVIEWNO - WRNO = -7 or -8, then APPRO = 0.

REVIEWNO: THE NUMBER OF REVIEW OPTIONS USED

WRNO: THE NUMBER OF WRONG ANSWERS IN A LESSON
(RANGE: 0 TO 8)

APPRO: APPROPRIATENESS OF THE USAGE OF CONTROL OPTIONS

EFFECTIVENESS OF THE USAGE OF CONTROL OPTIONS

EFFECTIVENESS = (ACCUR + APPRO) / 2

ACCUR: ACCURACY OF SELF-ESTIMATES OF UNDERSTANDING

APPRO: APPROPRIATENESS OF THE USAGE OF CONTROL OPTIONS

APPENDIX 3

QUESTIONS AND PROMPTS ADAPTED FROM THE METACOMPONENTIAL INTERVIEW:

QUESTION #1:

When Albert was 6 years old, his sister was 3 times as old as he.

Now he is 10 years old and he figures that his sister is 30 years old.

How old do you think his sister will be when Albert is 12 years old?

PROMPTS:

1. Do you have to watch out for mistakes when you do this problem?
2. Is there something in the problem that could trick you if you were not careful?
3. Is Albert right when he figures that when he is 10 years old his sister is 30 years old?
4. Will his sister always be 3 times as old as Albert?
   Is that a mistake? Should you multiply or add years?
5. Don't make a mistake.
   When Albert was 6, his sister was 18.
   12 years older.
   What would his sister be 1 year later, when Albert was 7 ?
   (19) 12 years older. One year later?
   (Continue if child does not understand, until solve 10/22 problem of Albert's.)

QUESTION #2:

Every classroom in Mary's school will have 2 girls for every boy.

Mary found out that there will be 8 girls in her class, so she figured there would be 16 boys.

Her sister's class will have 10 girls.

How many boys do you think will be in her sister's class?

PROMPTS:

1. Do you have to watch out for mistakes when you do this problem?
2. Is there something in the problem that could trick you if you were's careful?
3. Is Mary right when she figures that there will be 16 boys in her class?
4. Will a classroom with 2 girls for every boy have 2 times as many boys?
   Is that a mistake? Or half as many boys?
5. Be careful not to make a mistake.
   If there were 2 girls, and there are 2 girls for every boy, then there would be 1 boy.
   Half as many boys.
   If there were 4 girls, then there would be 2 boys.
   Half as many boys.
   (Continue if child does not understand until the 8/4 problem of Mary's is solved.)

QUESTION #3:

At our school the track is in a circle
with six flags spaced equally around it.

Yesterday, Frank started at the first flag
and raced around the circle.

He took 2 minutes to get to the third flag.

He thought it would take him 2 more minutes to get
to the sixth flag if he kept on at the same rate.

How long did it take him to get all of the way
around the track?

PROMPTS:

1. Do you have to watch out for mistakes when you do this problem?
2. Is there something in the problem that could trick you if you were not careful?
3. Is Frank right when he figures that it would take him 2 more minutes to get to the sixth flag?
4. Is it the same distance from the first to the third as from the third to the sixth flag? Is that a mistake? Where does he start? How many flags is it to the third flag starting at the first flag?
5. Don't make a mistake.
   Pretend Frank starts at the first flag,
   then goes to the second, then the third flag.
   That takes him 2 minutes.
   How long will it take him to get to the fourth,
   then the fifth flag?
   (The sixth?)

QUESTION #4:

Betty used to weigh 32 pounds
standing on one foot.

Frank said she would have weighed
64 pounds standing on both feet.

Now Betty weights 40 pounds standing on one foot.

How much do you think she weighs now
standing on both feet?

PROMPTS:
1. Do you have to watch out for mistakes when you do this problem?
2. Is there something in the problem that could trick you if you were not careful?
3. Is Frank right when he figures that Betty would weigh 64 pounds standing on both feet?
4. Will people always weigh twice as much standing on 2 feet as they do standing on 1 foot?
   Is that a mistake?
   Does that change what they would weigh?
5. Don't make a mistake.
   Would you get heavier standing on 1 foot, then 2 feet, then maybe on your hands and feet?
   Does that change how much you weigh?

Title:

Personalizing Math Word Problems

Author:

Cecilia L. Lopez

Introduction

Personalizing the context of instruction has been found to facilitate the reading comprehension of fourth-grade children who had been previously identified as poor readers (Bracken, 1982). There is also evidence that personalization increases the continuing motivation of high school students to return to task (Herndon, 1987).

Why should personalizing the context of instruction affect learner outcomes? Miller and Kulhavy (in press) hypothesized that personalization improves memory by increasing the associative strength during encoding of the personalized material and closely related content in a prose sentence. In a second experiment extending personalization to connective text, Miller and Kulhavy (in press) permitted subjects to encode information in terms of their own unique experiences, again incorporating the example that best fit the referent stimulus. In both studies, they found that incorporating personalized representations during encoding led to significantly greater recall of related information.

According to the National Assessment of Educational Progress (1975), solving story problems is a major weakness in the mathematical achievement of students. In analyzing the results of the National Assessment of Educational Progress (NAEP), Carpenter, Coburn, Reys, and Wilson (1975) found that only 31% of a national sample of 13 year olds could correctly solve a one-step word problem involving a 1-digit divisor and a 4-digit dividend. As a reaction to the findings of the NAEP, the National Council of Supervisors of Mathematics (1977) placed solving word problems first on its list of the ten most basic skills in mathematics.

Since learning to solve word problems is well documented as being difficult (Ballew & Cunningham, 1982; Carpenter et al., 1975; Marshall & Smith, 1987; Wright & Wright, 1986), a number of researchers have attempted to explain the causes of such difficulties. De Corte, Verschaffel, & De Win (1985) found that ambiguously stated problems, and not a lack of computational skills per se, significantly contribute to the inability of children to comprehend the text of word problems.

Both reading ability (Ballew & Cunningham, 1982) and computational ability (Muth, 1984) have been found to be significant factors in contributing to skill in solving word problems.

Personalizing of word problems appears to ameliorate some of the difficulties youngsters have in solving such problems. Kintsch (1986) and Hudson (1983) report that word problems containing abstract situations or actions are twice as difficult (39% as opposed to 79%) for children to solve as are word problems incorporating actions or situations that are concrete and familiar to the child. Wright and Wright (1986) administered personalized test items to fourth graders and found significant improvement in students' ability to select correct arithmetic operations, but little effect on their computation skills. Ross and Anand (1987) and Anand and Ross (1987) found that a personalized context of instruction embedding familiar items, such as learner interests and background, increased the achievement of fifth and sixth graders to solve verbally stated math problems. However, subjects in both studies by Ross and Anand were enrolled in a university affiliated school. Thus, it may be inappropriate to generalize their findings to children attending schools in lower socioeconomic areas.

Personalizing the context of instruction has been explored both with groups and with individuals. In a program on conditional syllogisms, Herndon (1987) personalized the context of practice items based on the most common interests of the subject pool, rather than on individual interests. Herndon (1987) found that personalization significantly affected the continuing motivation of high school seniors to return to task, but did not significantly improve their achievement. López (1989) personalized word problems, using individual responses to a biographical inventory. Her results yielded significant differences favoring the personalized treatment in both achievement and student attitude, but no significant differences in continuing motivation.

The rationale for using group instead of individually personalized context is one of expediency and efficiency. Incorporating group interests involves the development of a lesson or lessons that can be used for the entire class. Individual interests require that separate lessons be generated for each student. The group personalization should take considerable less time to generate than the individual one. Consequently, it is important to determine if the group method is as effective as the individualized one.

Research on sex differences in mathematics achievement has produced mixed results (Marshall, 1984). Maccoby and Jacklin (1974) found no sex differences until age 14, but differences favoring males after that age. Results from the 1979 NAEP data showed no significant sex-related differences among 9, 13, and 17 year olds in solving word problems (Linn & Petersen, 1986).

In a review of the 1978 NAEP results, Valverde (1984) found that Hispanic children were 9 percentage points below the national average (55% to 46%) in mathematics achievement at age 9. By age 17, Hispanics had dropped to 12 percentage points below the national average (60% to 48%). Matthews, Carpenter, Lindquist, Silver (1984) reported similar results from the 1982 NAEP data.

Despite these findings, few studies have examined ways to improve the mathematical performance of Hispanic students. In one such study, Hannafin (1983) found a trend toward superior performance for Hispanic sixth graders receiving an instructional system designed to provide hierarchically sequenced sets of computational skills over Anglos who had received traditional instruction. This trend occurred only on instructional tasks which were relatively novel or independent of prerequisite skills. López (1989) investigated the effect of individualized personalization on the performance of Hispanic eighth graders on mathematics word problems. Her data revealed significant differences favoring personalized over non-personalized instruction on both student achievement and attitudes.

The primary purpose of this study was to investigate the effects of three levels of personalization (individual, group, non-personalized) on the achievement of seventh grade Hispanic boys and girls on mathematics word problems. Data were also collected on subjects' attitudes toward the instruction. A pretest was employed to control experimentally for potential, initial achievement differences by treatment or sex. Subjects were blocked by sex on the basis of their pretest scores, then randomly assigned within each block to the three treatments.

Method

Subjects

One hundred twenty-three seventh grade Hispanic students from a rural junior high school with a primarily Hispanic enrollment near Phoenix, Arizona were the final group of subjects for this study. Subjects were from 10 math classes taught by four teachers.

Materials

Biographical inventory. A biographical inventory based on the work of Anand and Ross (1987) and Ross and Anand (1987) was designed for this experiment. Respondents were asked questions regarding their background and interests. Topics included the names of friends and favorite places, foods, objects, activities, and events.

Instructional lesson. Three parallel versions of a unit on division of whole numbers were developed. The non-personalized version, serving as a template, was written first. The individual and group versions were then written with nouns, pronouns, prepositional phrases, and dates inserted as appropriate in the original non-personalized context. Familiar items, including birth dates and city of residence, were derived from Biographical Inventory items.

Variations in treatments were manipulated by changing the referents of example and practice problems. However, the numerical values and methods of measurement (e.g., number or weight) were identical for all treatments.

The non-personalized treatment used the standard referents found in math textbooks. An example of a typical non-personalized referent follows:

> Jim expects 36 friends to come to a party. If each friend will get a 6-ounce (oz) serving of soda, how many 12-oz cans of soda are needed?

In the individual treatment, nouns and pronouns were replaced or modified with the familiar items students provided in the Biographical Inventory:

> Gabriel expects 36 friends to come to his birthday party on March 7. If each friend will get a 6-ounce (oz) serving of Dr. Pepper, how many 12-oz cans of Dr. Pepper are needed?

The instructional lessons for the individual condition were computer generated so as to provide a feasible way of personalizing the lesson context for individual experiences and interests.

The group treatment was based on the responses of the majority. Nouns, pronouns, or noun modifiers were replaced with the most familiar objects, places, and persons the majority of students provided in the

Biographical Inventory. An example of how variations in the group treatment were manipulated follows:

> Miguel expects 36 friends to come to his birthday party in December. If each friend will get a 6-ounce (oz) serving of Pepsi, how many 12-oz cans of Pepsi are needed?

The lesson covered procedures in solving one-step and two-step word problems involving division of whole numbers. Instruction on the strategy for solving both item types (one-step and two-step problems) contained the rule and its application with appropriate examples. Practice problems, three for each item type, followed. Each of the eight problems was placed on a separate page with enough open space to allow students to work the problem directly on the page. Answers to all practice problems were provided at the end of the lesson booklet.

Review. Prior to administration of the posttest, the seven-page review over the lesson content was administered. Three versions of the review were developed (individual, group, and non-personalized) to parallel the lesson content. The review contained a summary of rules and procedures for each item type and four practice problems, two for each item type. As in the instructional material, answers to all problems appeared at the end of the booklet.

Procedure

The Biographical Inventory was administered to students three weeks prior to administration of treatments. Besides biographical data, information regarding favorite objects, places, persons, and events were obtained.

Subjects were blocked by sex then randomly assigned within blocks to one of three levels of personalization (individual, group, or non-personalized).

The three versions of the instructional lesson were administered on a within-class basis in regularly scheduled math classes three weeks after the administration of the Biographical Inventory. The cover sheet on each booklet contained the student's name, class period, and task related instructions which the experimenter read to all subjects. Students were told that they were helping to evaluate a new lesson. Additionally, they were told that after completing the lesson and review, they would take a test and that their test scores would count toward their grade.

The review was given on the following day. The posttest was distributed to each student immediately after completion of the review material.

Criterion Measures

Achievement. The 16-item constructed-response posttest served as the criterion measure for achievement. The test covered the same mathematics operations as the instructional materials. It consisted of eight one-step and eight two-step word problems. None of the 16 problems involved remainders. All problems were in the non-personalized form. The inter-item reliability for the posttest, calculated in an earlier study by López (1989), is .77.

Attitudes and continuing motivation. This 4-point scale, containing 11 items, assessed level of interest; level of difficulty; number of familiar persons, places, or things; perception of the importance of the lesson; level of importance attached to seeing one's name in print; how much subjects liked the lesson; preference for personalized and non-personalized problems; and preference for word and number problems. Open-ended questions assessed what subjects liked most and least about the lesson.

Design and Data Analysis

The experimental design was a 3 Level of Personalization (Individual/ Group/ Non-Personalized) x 2 Sex (Male/ Female) x 2 Item Type (One-Step/ Two-Step) factorial design, with item type as a within-subjects variable. Achievement data were analyzed by multivariate analysis of variance (MANOVA) repeated measures. Attitude data were analyzed by separate analyses of variance (ANOVA).

Results

Achievement

Table 1 shows the mean scores by level of personalization, sex, and item type. The mean overall posttest scores by level of personalization were 9.49 for the individualized treatment, 9.61 for group, and 7.73 for non-personalized. The multivariate analysis yielded a significant difference for treatments, $F(2, 117) = 3.61$, $p < .03$. Univariate analyses revealed that the significant treatment effect occurred for two-step problems, *F*(2, 117) = 4.01, *p* < .021, but not for one-step problems.

Post hoc contrasts using Newman Keuls were performed to determine the source of differences between treatments. Both the individualized mean and the group mean were significantly higher at the .05 level than the mean for the non-personalized treatment. These differences are reflected in the two-step problem means of 3.23 for individualized subjects, 3.44 for group subjects, and only 2.06 for non-personalized subjects. The individualized and group means did not differ significantly from each other.

Overall mean scores by type of test items were 6.02 for one-step items and 2.89 for two-step items, a highly significant difference, *F*(1, 117) = 288.43, *p* < .001. The mean posttest score for females was 9.06 and the mean for males was 8.71, a non-significant difference.

Attitudes

The mean attitude scores, based on a score of 1 for the most positive response to each item and 4 for the most negative, are shown in Table 2. The table reveals that the overall mean scores across all seven items were 1.69 for the individualized treatment, 1.82 for the group treatment, and 1.87 for non-personalized instruction. Analysis of variance of these means yielded a highly significant difference, *F*(2, 117) = 3.12, p < .001. Post hoc contrasts using Newman Keuls revealed that the overall mean for the individualized treatment was significantly higher than those for both the group and the non-personalized treatments. The group and non-personalized means did not differ significantly from one another.

When the seven questionnaire items shown in Table 2 are considered individually, it can be seen that significant differences occurred for items 2, 3, 6, and 9. Post hoc contrasts showed that the individualized treatment mean was significantly different from the non-personalized mean (p < .05) on each of these items. Individualized subjects reported that the lesson was more difficult, there was more familiar content, they liked the lesson better, and they preferred personalized content. Means between the individual and group treatments and the group and non-personalized treatments did not differ significantly from one another on any of the four items.

Two additional items on the attitude questionnaire assessed preference for math word problems that were not personalized and preference to study more math word as opposed to number problems. ANOVA followed by Newman Keuls revealed that subjects in the individualized treatment (2.72) had a significantly lower preference for non-personalized problems than subjects in both the group (2.42) and the non-personalized (2.39) treatments, $\underline{F}(2, 117) = 5.05$, $\underline{p} < .008$. The three treatment groups did not differ significantly in their preference to study more word problems.

Frequency of constructed responses to the open-ended questions about what subjects liked most and what they liked least were also tabulated. Student responses indicated that what they liked most was the personalization of the lessons. This factor was cited 24 times, 19 by subjects in the individualized treatment and 5 by those in the group treatment. Subjects cited specific types of computations, notably division and multiplication, as what they liked least. A total of 25 responses fell into this category, 13 from the non-personalized treatment.

Discussion

The present research revealed a significant effect for personalization on student achievement on two-step problems, the more difficult problems in the instructional unit. It seems likely that at least two factors may have contributed to this effect. One is that personalized subjects liked the lesson more, as indicated by responses of individualized subjects to question 6 on the attitude survey -- "How much did you like the lesson?" This could have caused them to expend greater effort on the lesson, which could explain the fact that the individualized subjects reported the instruction to be significantly harder (question 2 on the attitude survey). If subjects receiving personalized instruction liked the instruction more and invested more effort in it, they could reasonably be expected to demonstrate improved performance.

A second possible contributing factor is that personalizing the problems may have increased subjects' level of understanding of them. When the problems are personalized by using familiar names, objects, and situations, the problem situation may be more familiar to the subjects. They may therefore be more able to deduce the necessary mathematical operations.

An explanation from cognitive theory suggests how personalization may influence learning by affecting encoding and retrieval. Miller and Kulhavy (in press) demonstrated that individualized personalization increases the retrievability of associate information by stimulating stronger and more memorable encoding. If personalization does provide the learner with more memorable illustrations of rule application, then more effective semantic processing of the problem situation may occur.

López (1989) found in an earlier experiment that individualized personalization of instruction was effective in improving the achievement of Hispanic children. The present results indicate that personalization is also effective with Hispanic students on a group basis as well as on an individual one. Thus, this finding extends to group personalization the earlier results obtained with individualized personalization by López (1989) and by Anand and Ross (1987) and Ross and Anand (1987).

Males and females in the present study did not differ significantly in their overall performance or their performance on particular types of problems. This finding is consistent with the results of the National Assessment of Educational Progress (NAEP) from 1973, 1978, and 1982. The NAEP, a comprehensive national test administered to a very large sample, mainly uses constructed-response items for word problems (NAEP, 1977), as did the present study. The NAEP data consistently yielded no significant sex-related differences among students at ages 9 and 13 in solving math word problems (Linn & Petersen, 1986; NAEP, 1983). Several studies published in the 1970s also reported no sex-related differences in mathematics achievement in the elementary grades (Hilton & Berglund, 1974; Maccoby & Jacklin, 1974).

Other researchers, however, report sex-related differences, generally favoring males in mathematics achievement. Fennema and Sherman (1977), Hilton and Berglund (1974), and Maccoby and Jacklin (1974) all report significant differences favoring males starting at grade 7. Benbow and Stanley (1982) report significant differences favoring males with mathematically gifted and highly motivated seventh and eighth graders. All of these results favoring males were from research using multiple-choice tests.

The variations in findings regarding sex-related differences may be a function of either the differing nature of the tests (constructed-response versus multiple choice) or of the differing subject populations. The most comprehensive sample across time, grade levels, number of subjects, and geographic sites was from the NAEP studies, which consistently yielded no sex-related differences on primarily constructed-response items. That boys performed better than girls on several studies involving multiple-choice tests may relate to the fact that these tests require somewhat different cognitive operations than constructed-response tests. The correct answer can often be derived in the former by examining the response choices and estimating the most reasonable choice, whereas constructed-response tests require computation of the correct answer. It is possible that males are better at the estimating skill, but not on the computations required in constructed-response tests.

The attitude data generally favor individualized personalization. Subjects under individualized personalization had significantly more positive overall attitudes than those under the other two treatments. Individual subjects liked the lesson better, recognized more familiar content, preferred personalized problems, and had a lower preference for the prospect of non-personalized problems in future math content. The most plausible explanation for the unexpected finding that subjects in the individualized treatment reported the lesson to be more difficult would seem to be that the personalized subjects expended greater effort on the lesson because of the personalization.

An interesting aspect of the high attitude ratings for individualized personalization is that they were obtained with content that is generally unpopular with students. Story problems, especially multi-step problems, are considered by students to be difficult (Ballew & Cunningham, 1982; Marshall, 1984; Marshall & Smith, 1987) and boring (Cheek & Castle, 1981). Nevertheless, the attitudinal responses of personalized subjects in this study indicated that the instruction was interesting and that they liked it.

The present results have implications for educational practice generally. The simplest application is for instructors to learn the interests of their students, either through a formal survey of interest or more informal means, and incorporate them into instruction whenever possible. The data from this study suggest that use of common interests of the group in this manner is also effective. More sophisticated application could involve the design of computer software that incorporates individual or group interests into word problems and other practice material while maintaining the integrity of the content to be learned.

Both the present study and the earlier research by López (1989) indicate that personalization in mathematics instruction is effective in improving the performance of Hispanic children, especially with two-step math problems. Both studies were conducted over relatively brief time periods of two instructional lessons each. Further research should be conducted to investigate the extent to which positive effects would be sustained over an extended time period and with different subject matter. Research investigating these issues should help to clarify the conditions under which personalization of instruction is most effective in maximizing improved classroom performance.

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Table 1

Means and Standard Deviations of Posttest Scores by Level of Personalization, Sex, and Test Item Type

	Level of Personalization						
	Individualized		Group		Non-Personalized		
Sex	1-Step	2-Step	1-Step	2-Step	1-Step	2-Step	Total
Females							
M	6.23	3.36	6.24	3.38	5.62	2.46	9.06
SD	1.85	2.48	1.70	2.65	2.00	2.23	3.80
Males							
M	6.29	3.09	6.07	3.53	5.70	1.65	8.71
SD	1.49	2.36	1.58	2.10	1.42	2.25	3.40
Total							
M	6.26	3.23	6.17	3.44	5.67	2.06	8.90
SD	1.66	2.40	1.63	2.41	1.71	2.24	3.63

Table 2

Questionnaire Responses by Treatment

Questionnaire Item	Individ	Group	Non-Pers	*F*-value	*p*-level
1. Interesting-Boring	1.93	1.89	2.07	.85	NSD
2. Easy-Hard	2.02	1.75	1.75	3.30	<.04
3. Familiar Content	1.53	1.81	2.16	5.80	<.004
4. Importance of Problem Solving	1.28	1.44	1.23	1.69	NSD
5. Importance of Name in Print	2.07	2.25	1.93	.97	NSD
6. Liking for Lesson	1.63	1.94	2.02	3.81	<.025
9. Preference for Personalized Problems	1.37	1.69	1.93	5.67	<.004
GRAND MEAN	1.69	1.82	1.87	3.12	<.001

Note. Questions 7 and 8 were open-ended items.

Title:

Learner Preferences for Varying Screen Densities Using Realistic Stimulus Materials with Single and Multiple Screen Designs

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Abstract

Learner preferences for varying screen density levels were examined using multiple screen designs (high external validity) and single screen designs (high internal validity). When viewing multiple screens for each design in Study I, subjects indicated the highest preference for medium density screens while tending to select higher-density over lower-density screens in individual comparisons. When viewing only the first screen of each density level in Study II, subjects again expressed preferences for higher-density over lower-density designs. Suggestions are provided concerning the use of realistic and nonrealistic content for the stimulus materials as well as implications of using externally and internally valid screen designs for future research on computer-based instruction screen design.

The continuing expansion of the microcomputer into schools, businesses, hospitals, and homes has created a market for instructional software ranging from beginning mathematics programs to sophisticated simulations of hospital emergency room events. A review of these instructional packages indicates the integration of graphics, sound, animation, and both effective and poor applications of instructional design (Bork 1987; Burke, 1981; Keller, 1987). Unfortunately, software designers have a tendency to design computer screens based on principles derived from print based research (e.g., Hartley, 1985), yet a comparison of the attributes of the two media reveals several important differences. Computer displays (a) are limited to one page at a time, (b) have restricted backward paging and review, (c) are limited to layouts of 40 or 80 columns by 24 rows, (d) provide limited cues as to lesson length, (e) are typically limited to one typeface and one or two typesizes, and (f) offer relatively poor resolution. In contrast to the printed page, the computer has the capability to generate dynamic "pages" (e.g., windows, screen building, and animation), which can be increased in number with a relatively smaller effect on distribution costs.

Computer Screen Design

The literature on computer screen design tends to follow one of two approaches. The first approach focuses on typographical variables that the designer can manipulate to create an effective screen design. Based on research and subjective views, several authors have recommended that displays feature liberal white space, double spacing, a standard ASCII typeface, and left-justified text (Allessi & Trollip, 1985; Bork, 1984, 1987; Grabinger, 1983; Heines, 1984; Hooper & Hannafin, 1986). Given the recent introduction of bit mapped graphics, information concerning the manipulation of typefaces, type size, leading, and similar typographical variables will also become more accessible.

A second approach to computer screen design is the manipulation of the content. One such method is chunking the material into meaningful thought units which are then presented with blank (white) spaces bordering each (Bassett, 1985; Feibel, 1984; Grabinger, 1983). Although Falio and DeBloois (1988) suggest chunking as an effective means of designing displays, research on chunking and similar methods have failed to show clear advantages under either print or CBI (cf. Basset, 1985; Carver, 1970; Fiebel, 1984; Gerrel & Mason, 1983; O'Shea & Sinclair, 1983). It seems important to consider that chunking does not change the instructional content; rather, it changes the way the content is presented on the screen. In contrast, Morrison, Ross, & O'Dell (1988; Ross, Morrison, & O'Dell, 1988) varied the text density in presentations as represented by the length of the materials, redundancy of explanations, and depth of contextual support for main ideas. They found that the lower density text was read significantly faster than conventional text with no reduction in achievement. Subjects also chose lower-density over higher-density text 65% of the time.

In summary, these two approaches, typographical variables and content manipulation, have provided useful guidelines for screen design; however, they have not addressed the issue of how much information, "screen density," the expository frame should contain. For example, the International Reading Association Computer and Technology Reading Committee (1984) recommends using "clear and legible" displays with "appropriate margins and interline spacing", but provides no operational guidelines or specifications to define these qualities. To provide designers with clearer recommendations for optimum density levels, the screen density construct must be operationalized and precisely defined.

Screen Density as a Design Variable

One method of evaluating screen designs is to calculate the density of the total screen by determining how many of the screen spaces contain a character or are adjacent to a character (Tullis, 1983). It is assumed that instructional displays are relatively uniform in density due to the use of prose, as compared to instrumentation readout displays which often chunk the information into different sections of the screen.

Human factors research suggests that performance error rates increase as the density of a display increases (Burns, 1979, Coffey, 1961; Mackworth, 1976; Ringel and Hammer, 1964). Research, however, on the upper limit of screen density has yielded disparate recommendations ranging from 15% (Danchak, 1976) to 31.2% (Smith, 1980, 1981, 1982) all the way to 60% (NASA, 1980). Two reasons for these inconsistencies are suggested. First, the displays have often involved instrumentation screens and information displays that are too esoteric (i.e., unique to a specific environment) to be generalizeable to instructional screens. Second, several of the studies have used isolated screen displays of unrealistic stimulus materials which have low ecological validity (see Ross & Morrison, 1989).

In a realistic lesson the number of frames increases as the amount of white space increases (i.e., screen density is decreased). Thus, manipulation of screen density in a single frame presentation fails to account for the concomitant effect of the increase or decrease in the number of screens required to read the same information.

Accordingly, in contrast with previous research, the present study was designed to examine learner preferences for different screen densities used to present a fixed amount of material. Depending on the particular density level represented, from one to four frames of information were required to view the content.

Another concern in investigating screen density preferences is the possible influence of the type of material presented on how different screen designs are viewed. For example, Grabinger's (1983) evidence for supporting low density screens was obtained using a typographical notation developed by Twyman (1981) to create a content-free screen representation of a CBI screen. Specifically, screens were designed with x's and o's to resemble actual lessons. However, when reacting to displays of abstract or artificial materials, subjects may prefer wide margins and other lower density attributes due to the greater saliency of aesthetic properties when there is no need to understand the content. In contrast, judgments of realistic materials would appear to demand greater awareness of and reliance on contextual properties (e.g., proximal supporting text) that helps to increase the meaning of the information being read. Thus, it is not clear that preferences for low-density screens similarly apply to realistic lesson materials, especially since the low-density designs present the material in smaller thought units and consequently also necessitate an increased number of lesson frames.

Accordingly, to extend Grabinger's (1983) research, the present study used realistic materials from an actual course in the subjects' academic program. We expected that with fixed content and realistic displays, preferences for lower-density screens would not be as high as previous research in the instructional design literature generally suggests. A third research interest was the preferences of users differing in degree of CBI experience, namely graduate instructional design students versus undergraduate education students.

Study I

Method

Subjects and Design

Subjects were 23 graduate and 23 undergraduate education majors (29 females and 17 males) who volunteered to participate in the study. A paired-comparison design (Nunnally, 1967) was employed involving a total of six unique pairings of four density levels presented on an Apple IIe monochrome screen. For each of the six comparisons, subjects were presented with two different screen designs and asked to indicate their preference. The six comparisons and the two density levels within each were presented in a random order. To begin the session, subjects completed a 9-item attitude survey presented on the computer. They were then presented the six comparisons and asked to indicate their preference on each.

Materials

Materials used in this study are described below in the order in which they were used.

Profile Data. A 9-item survey was used to determine subjects' attitudes towards using the microcomputer. Each item was presented on the computer screen. Subjects reacted to each using a five-point scale with 5 representing the most positive reaction. Six of the items concerned the subjects' attitudes towards using the microcomputer for work or school. The remaining three items concerned their attitudes towards learning how to use a microcomputer.

Screen Displays. A single screen selected from a computer-based lesson used in previous studies on text density (Morrison, Ross, & O'Dell, 1988; Ross et al., 1988) was selected as the basic content for this study (see Figure 1). The material was from an instructional unit on statistics (Ross, 1983) currently used in an undergraduate education course at the same university in which the study was conducted. To determine the screen density of the core frame, all characters and spaces contiguous to the characters were counted and then divided by the total number of characters the screen could display (960 for a 40 column x 24 row format). The resultant density level was 53% (see Figure 1). The 53% density screen was then divided into two screens, three screens, and four screens to reduce density level by varying degrees. Screens were divided at logical points rather than according to specific character counts which helped maintain a uniform density level across the screens. The density levels for the multiple-screen displays were determined by averaging the density of each screen. The two-screen display had an average density level of 31% per screen, the three-screen display averaged 26%, and the four-screen display averaged 22% (see Figure 1).

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The screen display software included a management component which stored the data collected at each session on disk for later retrieval. A second program was used to provide a printout of each subject's responses, reformat the data for uploading to a mainframe for later analysis, and add the data to an archive file for future reference.

Insert Figure 1 About Here

Procedure

From 2 to 15 subjects attended each session in one of two computer labs. Both labs were equipped with Apple //e microcomputers with 12 or 13 in. monochrome screens, either one or two 5.25 in. disk drives, and 64K to 128K of memory. Proctors began the session with a brief description of the purpose of the study after which they booted the computers. The first screen asked subjects for their name, sex, and status (graduate or undergraduate). Then, subjects completed the 9-item attitude survey presented on the microcomputer. Subsequent screens described the experiment and explained the information contained on each screen.

The six screen comparisons were presented in a random order. The density level randomly selected to be presented first in each each comparison was labeled Design #1 at the top of the screen and the second density level was labeled Design #2. The number of screens in the design and the particular screen presently being viewed was indicated in the lower left hand corner (e.g., "1 of 1", "2 of 3", etc.). A prompt in the lower right corner of the screen indicated that a key press would result in advancement to the next frame. After viewing both designs, subjects had the option of indicating their preference for one of the two designs or for reviewing either or both designs. Once a preference was indicated, presentation of the next pair of designs was initiated. This process was then repeated for each of the remaining five comparisons.

Results and Discussion

Paired Comparison Selections

Table 1 shows the proportion of subjects (total n = 46) who selected each density level when paired with each of the alternative levels. These proportions reflect a curvilinear pattern, with preferences tending to favor the two middle density levels (especially the 31% level) over the lowest (22%) and highest (53%) levels. Specifically, the 31% level was favored by the majority of subjects (from 52 to 74 percent) over each of the other three levels: the 26% level was favored by the majority (54 to 56 percent) over each of the two extreme levels.

Insert Table 1 about here

To provide an overall comparison of the density selection rates, a scaling procedure derived from Thurstone's model of comparative judgment (see Nunnally, 1967; Guilford, 1954) was used to represent their relative distances on an interval scale. The procedure involves first converting the proportion values (as shown in Table 1) into normal curve deviates. For example, a stimulus that is chosen over a comparison stimulus by 84% of respondents would have a normal (z score) deviate of 1.00, representing the area in the distribution that is 1 standard deviation above the mean. The normal deviates derived for each stimulus are then averaged to produce an overall mean. To prevent having negative values on the final scale, the absolute value of the largest negative mean is added to each of the means. Consequently, the "least preferred" stimulus on the final scale will always have a final mean value of 0.0. For the present preference scale, as shown in Figure 2, the scale values ranged from 0.0 (22% density) to .49 (31% density). Although the 26% level was preferred over the 53% level in their direct comparison (see above), both had identical scale scores of .19. Based on these overall scale placements, the 31% level can be considered the most frequently preferred and the 22% level the least frequently preferred.

Insert Figure 2 about here

To verify these trends statistically, tabulations were made of the total number of times each density level was chosen by subjects. Because each level was judged on three out of the six comparisons, its maximum score for a given subject was 3.0. Resultant means were 1.17, 1.46, 1.91, and 1.46 for the four density levels, respectively (ordered from lowest to highest density). The density selection scores were then analyzed in two ways. First, a Friedman ANOVA by ranks, a nonparametric test (Hays, 1981), was used to compare their *ordinal rankings* within subjects. Although this test is less powerful relative to treating the scores as interval data in a parametric test, it was considered less likely to be biased by the built-in interdependency between individual subjects' four selection scores (i.e., if a subject's score for one density level was relatively high, his/her score for one or more other density levels would have to be relatively low to compensate). Results from the Friedman test were significant, $X^2(3) - 8.32$, *p* < .04, indicating that the frequencies with which the density levels were selected were different. This outcome was then substantiated by performing a repeated measures multivariate analysis of variance (MANOVA) on the original selection total scores, F (3,43) = 3.34, $p < .03$. Follow-up comparisons of means were made using the Tukey HSD procedure. Only the difference between the 31% and 22% levels was significant ($p < .05$).

The above results provide information on how the individual density levels were judged relative to one another. A somewhat different question concerns whether or not overall preferences tended to favor, as the literature suggests, lower-density over higher-density designs. However, tabulations across subjects on the six paired-comparison trials indicated the opposite pattern: 156 (57 percent) selections favored the higher density design whereas only 120 (43%) favored the lower density design, $X^2(1) = 4.44$, $p < .05$.

Individual Differences Outcomes

Further analyses examined density preferences and attitudes as a function of subject gender and academic group (graduate versus undergraduate). Dependent variables were the four density level total scores, the total number of lower density designs selected across trials, and scores on each of the nine attitude items. Using t tests for independent samples, none of the group effects for either individual difference variable was significant. Finally, correlations between the number of lower-density designs selected and attitude scores were consistently low and nonsignificant.

Summary

In contrast to recommendations in the literature (Allessi & Trollip, 1985; Bork, 1984, 1987; Grabinger, 1983; Heines, 1984; Hooper & Hannafin, 1986) for designing lower density screens, these results showed that subjects tended to prefer higher-density screens. The relatively stronger preferences for the 31% (intermediate) density level may suggest that subjects were attempting to balance aesthetic properties (i.e., perceived readability and visual appeal) with either or both (a) the degree of contextual support and (b) the number of screens in the lesson. If the latter were the key factor, then preferences for the lower density (more spacious) designs would seem likely to increase if corresponding increases in the number of screens were presented by presenting _only_ the first screen of each screen density level as in Grabinger's (1983) study. Study II was conducted to test this interpretation.

Study II

The primary interest in Study II was to determine the replicability of the Study I results when only the first screen of each density level was presented. It was predicted that in this case, stronger preference for the lower density screens would be indicated than in Study I, since reductions in density level would not require having to review a greater number of frames.

Method

Subjects and Design

Subjects were 27 graduate and 12 undergraduate education majors (34 females and 5 males) who volunteered to participate in the study and had not participated in Study I. The same paired-comparison design as in Study I was employed.

Materials and Procedures

The stimulus materials were the same as used in Study I with one change. Only the first screen for each density comparison was presented. The instructions were modified to indicate that subjects would view only the first screen of information in the six designs, but in a real lesson they would need to view several screens to obtain all of the relevant information.

As in Study I, the first screen asked subjects for their name, sex, and status (graduate or undergraduate). The 9-item attitude survey was then presented, followed by instructions for the paired-comparison task. The six screen comparisons were presented in a random order, with the density levels in each randomly designated as Design #1 or Design #2 at the top of the screen. Again, subjects had the option of viewing either or both designs as many times as desired before indicating their preference.

Results and Discussion

The proportion of subjects (total *n* = 39) who selected each density level in the separate comparisons is shown in Table II. Here, in comparison to the curvilinear trend of Study 1, the pattern is directly linear, with the higher-density design consistently preferred over the lower-density design. Application of the linear scaling procedure, as diagrammed in Figure 3, reflects this pattern, showing the scaled scores to increase, from 0.0 to .49, as density level increases. As in Study 1, the total number of times subjects selected each density level were tabulated. Overall means were 1.13, 1.49, 1.62, and 1.77 (out of a possible 3.0) for the four levels respectively. However, neither the Friedman analysis of ordinal rankings nor the repeated measures ANOVA on selection total scores indicated a significant difference between levels, although the latter approached significance ($p < .08$). Across all comparisons, however, subjects chose the higher-density design 145 (62 percent) times and the lower-density design only 89 (38 percent), X^2 (1) = 12.93, $p < .001$. Thus, compared to Study I, while no particular density level emerged as significantly more or less desirable than others, there was an even stronger tendency to select higher-density design of each pair.

Insert Figure 3 About Here

Individual difference comparisons were made for academic status, but not for gender due to the very small number of males (5 out of 39) in the sample. Differences were significant on the selection totals for two density levels. Undergraduates selected the 31% level an average of 1.08 times (i.e., on 36% of its comparisons) whereas graduate students selected it an average of 1.85 times (a 60% rate), $t(38) = 2.24$, $p < .05$. For the 53% level, the opposite pattern occurred, with the undergraduate students selecting it more frequently ($M = 2.33$, rate = 78%) than the graduate students ($M = 1.51$, rate = 50%), $t(38) = 2.00$, $p < .05$. No differences between graduate and undergraduate students were found on any of the attitude items or on the total number of lower-density designs selected across trials.

Discussion

In contrast to previous studies and recommendations in the instructional design literature (Allessi & Trollip, 1985; Bork, 1984, 1987; Grabinger, 1983; Heines, 1984; Hooper & Hannafin, 1986), subjects in the two studies indicated a strong preference for learning from high density screens as opposed to low-density screens. These results were generally consistent for males and females, and for inexperienced and experienced users. The suggestion is that the use of realistic stimulus materials may produce different results than obtained with nonrealistic stimulus materials (e.g., Grabinger, 1983) or with informational (e.g., machine status) displays (e.g., Danchak, 1976; Smith, 1980, 1981, 1982).

A question still remains as to why subjects indicated a preference for higher density screens over lower density screens in the individual comparisons. If only the results from Study I are considered, one might conclude that higher density screens were selected to avoid the additional effort (keypresses) and presentational discontinuities involved in viewing the additional screens of the lower density version. In Study II, however, only the first screen of each density level was viewed, yet even somewhat stronger preferences for higher density screens occurred. Thus, the "additional effort" hypothesis suggested from Study I was not supported.

A more likely interpretation suggests consideration by subjects of the informational qualities of the display. Figure 4 shows two screens of approximately 31% density, containing realistic content and the other nonrealistic content; and two comparable screens of approximately 53% screen density. Seemingly, in visually comparing the two nonrealistic or "content free" displays, the lower density screen will appear more spacious and easier to read. When the two screens containing realistic content, however, are compared, one must not only consider aesthetic properties, but also the amount of contextual support needed to learn. A high density design increases contextual support by presenting maximum information (both main ideas and supporting explanations or examples) on a single frame. By glancing forward or backward the student can obtain cues that facilitate the processing of a word or phrase. Low density frames minimize this contextual support which should normally disrupt the processing of information. (Consider, for example, the extreme case of reading a novel in which only one or two sentences appear on each page). It thus appears that the contextual properties of the current displays of realistic material had a greater influence on learner preferences than the aesthetic properties. Changing the context of the material or the processing demands of the task, however, might alter the relative importance of these two features. Further research is needed to substantiate this hypothesis.

Insert Figure 4 About Here

The present research calls attention to two salient problems for instructional designers and researchers in the area of CBI screen displays. First, instructional designers who base design decisions on human factors research should use caution when attempting to apply heuristics proposed for informational displays to the design of instructional displays. Informational displays, which are designed for "quick glance" reading, present information in a consistent location and vary only part of the display (e.g., monitor readouts). Instructional displays, however, are designed for slower or more deliberate processing of all the content. Thus, each has a different purpose and will typically require different design heuristics.

Second, for the reasons proposed in the preceding paragraph, subjects may apply different perspectives when reacting to nonrealistic as opposed to realistic stimulus materials in screen design studies. Although nonrealistic materials have internal validity advantages for basic research, results need to be verified with ecologically

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valid materials before heuristics for screen designs are generated (Ross & Morrison, 1989).

It should also be noted that screens formatted in symbolic notation such as Twyman's (1981) may not be directly comparable to text screens of the same computed text density level due their use of solid lines of x's or o's as contrasted to lines of nonsense words or real words separated by spaces. It is recommended that researchers interested in content free stimulus materials consider the potential of approximations to English (Morrison, 1986; Shannon & Weaver, 1964) that maintain the same structure as a realistic screen without conveying meaning.

As a final point, the absence of an operational definition of low and high density screens makes it difficult to compare results across studies and to translate findings into effective design practices. To provide for consistency in design and research, the adoption of a standard method of calculating screen density is needed. Tullis' (1983) method seems appropriate for this purpose by basing screen density on the number of characters and contiguous spaces on the screen. Consistent terminology should also be used in classifying and referring to screens of varying density. For example, screens with density levels 22% or less might be labeled as low-density, those with densities between 26% and 50% as medium density, and those above 50% as high density. Although these cutoffs are arbitrary, they approximate discriminations made by subjects in the present research and would help to eliminate the current situation of one researcher's "low-density" display being structurally identical to another's "high-density" display.

It is suggested that future research on CBI screen design take three directions. First, researchers should focus on identifying optimum screen densities as opposed to minimum or maximum tolerable densities. This approach differs from earlier research in the field of instructional technology which focused on such factors as the minimum size for projected letters (cf. Phillips, 1976). Based on the present findings regarding learner preferences, the optimum density level appears to be between 31% and 53% (medium to high). Second, additional research is needed to test the generality of these findings using different types of stimulus materials (realistic in various subject areas and levels versus nonrealistic). Quantitative oriented subject material, for example, may require different design considerations than would lessons in English or history. Although the present results were similar in Studies I and II, the use of multiple frames for high external validity seems advisable to permit generalization of findings to actual lessons. Third, current research on CBI screen design has focused almost exclusively on learner preferences for different designs. Future research needs to investigate the implications of these designs for achievement as well.

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Table 1

Proportion of Times Density Levels Within Each Paired Comparison Were Selected in Study 1

Paired Comparison											
22%	26%	22%	31%	22%	50%	26%	31%	26%	50%	31%	50%
.46	.54	.26	.74	.46	.54	.35	.65	.56	.44	.52	.48

Title:

Affective and Cognitive Influences of Textual Display in Printed Instruction

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Affective and Cognitive Influences of Textual Display in Printed Instruction

Abstract

This study examined the influence of textual display in printed instruction on the attention, performance, and preference of 90 preservice teachers, and investigated differential effects of textual display for high and low ability learners.

Textual display was manipulated through three versions of printed instruction. Ability was measured by GPA. Attention was measured by the Attention subscale of the Instructional Materials Motivation Scale (Keller, 1987). Performance was measured by an objective-referenced test of recall. Preference was measured by items from the IMMS Attention and Confidence subscales.

Data were analyzed using analysis of variance and chi-square. Results indicated that there was an interaction between ability and textual display for performance (p=.009), but not for attention. Results also indicated that textual display significantly influenced performance (p=.004), but not attention. The Moderate Textual Display produced significantly higher performance scores for low ability subjects (p<.001). Results of the test for preference revealed that, of the three versions, learners preferred the text exhibiting the Moderate Textual Display.

Affective and Cognitive Influences of Textual Display in Printed Instruction

Introduction

Nationwide surveys show that over 50% of learning activities are based on the use of textbooks and related print materials, and that in some areas, teachers rely almost exclusively printed stimuli (Bullough, 1988; Knirk & Gustafson, 1986; Nelson, Prosser, & Tucker, 1987). Researchers report that learners tend to resist print more than they would resist a lesson from some other instructional medium (Knirk & Gustafson, 1986). Learners perceive print instruction to require more mental effort than other delivery systems, and this perception influences their willingness to learn from textual stimuli (Salomon, 1983). Since learner interest (or lack of interest) in the instruction can influence performance (Keller, 1983), designers must consider the motivational or affective aspects of learning from text when developing print instruction (Hartley, 1987, Sless, 1984; Stewart, 1989).

Keller's (1983) theory of motivation illustrates the interrelationships of motivation, performance, and instructional influence by describing the effects that learner characteristics and environmental factors have on motivation and performance. Keller (1986) identified four categories of learner and/or environmental variables which affect motivation to learn: attention, relevance, confidence, and satisfaction. Analysis of the learner's motivational status, in regards to these four requirements, determines personal input deficiencies which might be alleviated by environmental inputs, such as instructional stimuli, to promote successful performance.

With printed instructional stimuli, a personal input deficiency in Attention may result from the instruction's appearance. This deficiency might be alleviated by a textual display (overall visual appearance of printed materials) that arouses and maintains the learner's interest. This interest could lead to increased motivation to learn from the textual instruction, which might positively influence performance.

The primary purpose of this study was to examine the influence of textual display in printed instruction on learner attention to the instruction and performance of the instructional goal. Secondary purposes were to investigate any differential effects of textual display for high and low ability learners and to determine learner preference for textual display.

Background

Textual display has been defined as "the manner in which text information is presented on a page or in a chapter" (Duchastel, 1982, p. 167). Grabinger's (1985) study of textual display on electronic screens revealed that three main dimensions affected student ratings of textual display: organization, structure, and spaciousness. The importance of easily-perceived organization and structure to learning from printed stimuli has been established (Brandt, 1978; Brooks & Dansereau, 1983; Gerrell & Mason, 1983; Glynn & Britton, 1984; O'Shea & Sindelar, 1983; Reder & Anderson, 1982; Rumelhart, 1980; Shimmerlik, 1978).

Spaciousness has also been found to influence learning from textual instruction. The level of crowdedness or spaciousness can be referred to as the density of the textual display, which is differentiated from the density of the textual information. Information density is the amount of elaboration provided in the printed instruction (Fisher, Coyle, & Steinmetz, 1977; Reder, Charney, & Morgan, 1986). Though the two types of density were not differentiated in their study, Morrison, Ross, and O'Dell (1988) compared high and low density displays. Results revealed no significant differences in achievement, though high density displays were preferred. This contradicts Grabinger's (1985) results which found that students prefer text designs with lots of white space and openness. Additional research could help clarify these differences.

Two dependent variables that might be examined in relation to textual display are attention and performance. Attention, perception, and learning are intertwined - practically and theoretically (Fleming, 1987). Motivation, including the arousal and maintenance of attention, are affected by novel, challenging, moderately complex stimuli (Berlyne, 1966; Deci, 1975; Gagne, 1985; Kagan, 1972;). Stewart (1988) states that arousing of interest and focusing of attention can be induced by an affective aspect of text; and Turnbull and Baird (1975) state that typographic techniques can be employed to make an instuctional text more interesting and challenging. Because features of text design, such as graphic cues, heading placement, and layout (Bovy, 1981; Brooks, Dansereau, Spurlin, & Holley, 1983; Coles & Foster, Fleming & Levie, 1978; Grabinger, 1985; Hartley, 1986; Wager, 1987; Thiagarajan, 1977;) can make printed materials novel, challenging, or moderately complex, textual display can have an affect on learner attention.

Jonassen (1982) proposes that cognitive processing can be "text induced." Design aspects of the text presentation can help the learner semantically encode the stimulus and conceive linkages between features of the stimulus that will later serve as cues for retrieval (Wager, 1987), so the textual display can be manipulated to facilitate comprehension (Duffy & Waller, 1985; Stewart, 1988). Textual organization and structure, which are logical and visually explicit, have been found to have an effect on learning (Brandt, 1978; Cocklin, Ward, Chen, & Juola, 1984; Glynn & Britton, 1984; Meyer, 1981, 1985; Singer, 1985; Winn, 1981; Witkin, Moore, Goodenough, and Cox, 1977). The structure and organization of printed instruction can be made explicit in text (Stewart, 1989b) through verbal and typographic cueing systems (Beck, 1984; Felker, 1980; Glynn, Britton, & Tillman, 1985; Grabinger & Albers, 1988; Loman & Mayer, 1983; Lorch & Chen, 1986). Textual display that shows explicit structure and organization can promote performance.

One individual difference that may have a moderating effect on attention and performance is student ability. Learner responses to textual display could be based on different capacities for processing information (Jonassen, 1982). Studies have shown that high and low ability students benefit differentially from typographical cues and from meaningfully segmented text (Beck, 1984; Gerrell & Mason, 1983; O'Shea & Sindelar, 1983; Wilson, Pfister, & Fleury, 1981). An uncomplicated textual display that explicitly exhibits the organization of the instruction may be more influential with lower ability students. The ability of high performance students to organize as they read and to use the cues provided may override any differences for textual display.

Method

Independent variables were textual display and ability. Textual display refers to the manner in which text information is presented on a page and was operationally defined as the arrangement of specified elements on the printed page (Turnbull and Baird, 1975). This variable was manipulated by varying text column width and position, horizontal and vertical spacing, and heading placement in three versions (Simple Textual Display, Moderate Textual Display, Complex Textual Display) of a printed self-instructional text (see Table 1). Entitled The Student Teaching Handbook, this text presented information on the expected outcomes and criteria for evaluation of the student teaching experience. Ability was defined as the subject's measured achievement and motivation to succeed in educational activities (Adams, Waldrop, Justen, & McCrosky, 1987) and was measured by cumulative grade point average. High and low ability subjects were identified as those, in each of the three groups, having the fifteen top and bottom GPAs, respectively.

Attention, performance, and preference were the dependent variables. Attention was defined as the arousal and maintenance of interest in instruction and was measured by the Attention subscale of the Instructional Materials Motivation Scale (Keller, 1987). The IMMS is a 36 item, Likert-type instrument which was developed to measure the presence or absence of the motivational components of attention, relevance, confidence, and satisfaction in instructional materials. The internal consistency for the instrument is .89 and the reliability of the Attention Subscale (12 items) is .88 (Keller, Subhiyah, & Price, 1989).

Performance was defined as achievement of the instructional goal and was measured by a 14 item multiple-choice, objective-referenced test of recall. Preference, which refers to learner perception of textual display across various descriptors, was operationally defined as learner selection of one of the three versions. This variable was measured by 18 items from the IMMS Attention and Confidence subscales.

The data were analyzed by analysis of variance and chi-square, using an alpha level of .05 for all tests. For the attention and performance variables, an interactive model was followed. Chi-square was used to test the preference variable.

Subjects were 90 students enrolled in the final field experience of their undergraduate teacher education program at a small public college in South Georgia. Student teachers were randomly assigned to one of three treatment conditions and the treatments and testing were administered during the Student Teaching Orientation. Each group received instruction from one of the three texts and were then given the Attention and Performance tests. Upon completion, copies of all three versions were distributed and used as a basis for response to the Preference measure. (A total of 128 student teachers were assigned and tested; but due to the high and low ability identification, data for only 90 - 30 in each treatment condition - were analyzed.)

Results

Results indicated that there was an interaction between ability and textual display for performance (p=.009), but not for attention (see Tables 2, 3, & 4). Results also indicated that textual display significantly influenced performance (p=.004), but not attention (see Tables 3 & 4). The Moderate Textual Display produced significantly higher performance scores for low ability subjects (p<.001). Results of the test for preference revealed that, of the three versions, learners preferred the text exhibiting the Moderate Textual Display (see Tables 6 & 7).

Discussion

Results did not suport the expectation that textual display would significantly influence attention. These findings may be explained by the situation and the subjects' entry level of motivation. It is likely that the anticipation of the student teaching experience induced such a high motivational state that subjects may have needed no alleviation of attention deficiencies by the instructional stimuli.

Analysis showed that textual display had a differential effect on the performance of high and low ability learners. These results show that a moderate textual display can improve performance of low ability learners.

The results of the preference test show that subjects had a clear prference for the Moderate Textual Display. This could mean that, eventhough they may have been intrinsically motivated to attend and perform, the students still had strong feelings about the instructional materials they would prefer to receive. This finding suggests thqt there are affective aspects of textual display in printed instruction and that text organization and structure and text density contribute to these affective dimensions.

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Table 1
Variations in Textual Display

	Textual Display		
Element	Simple	Moderate	Complex
Text column			
width	medium	medium	wide
position	central	side	central
Spacing			
vertical			
interlinear	double	single	single
paragraphs	indented	spaced	indented
horizontal			
right	unjustified	unjustified	justified
Headings	intact	marginal	embedded

Table 2
Means (and Standard Deviations) for Attention and Performance of High and Low Ability Preservice Teachers

	Textual Display			
	Simple	Moderate	Complex	Total
Attention				
High Ability	35	36	37	36
	(7.5)	(6.7)	(4.3)	(6.2)
Low Ability	36	38	36	37
	(6.0)	(6.6)	(8.4)	(6.9)
Performance				
High Ability	88	84	87	86
	(.05)	(.08)	(.07)	(.07)
Low Ability	77	86	79	80
	(.11)	(.06)	(.10)	(.10)

Table 3

ANOVA Summary for Performance

Source	SS	df	MS	F	p
Explained	.15	5			
Textual Display	.01	2	.005	.81	.45
Ability	.07	1	.08	12.43	.001
Interaction	.06	2	.03	5.04	.009
Residual	.53	83	.006		
Total	.68	88			

Table 4

Simple Main Effects Analysis of Performance

Source	df	MS	F	p
Textual Display				
Simple	28	.67	4.49	.001
Moderate	29	.72	1.97	.441
Complex	28	.69	1.82	.019

Table 5

ANOVA Summary for Attention

Source	SS	df	MS	F	p
Explained	63.3	5			
Textual Display	15.5	2	7.7	.18	.84
Ability	6.8	1	6.8	.15	.69
Interaction	41.2	2	20.6	.47	.63
Residual	3667.9	83	44.2		
Total	3731.2	88			

Table 6
Percentage of Learner Selection of Textual Display and Chi-Square Results

Items	Textual Display			Chi	p
	Simple	Moderate	Complex		
Positive					
1	41.4	52.3	6.3	30.03	.0000
2	25.2	70.9	3.9	73.32	.0000
4	32	62.5	5.5	44.79	.0000
5	29.7	64.1	6.3	51.45	.0000
7	25.8	69.5	4.7	56.18	.0000
8	38.3	55.5	6.3	42.82	.0000
11	28.3	66.1	5.5	38.59	.0000
12	26.8	67.7	5.5	52.01	.0000
13	31.7	35.7	32.5	.8262	.9349
14	31	63.5	5.6	49.41	.0000
17	27.8	67.5	4.8	52.76	.0000
18	27.8	66.7	5.6	63.56	.0000
Negative					
3	18.8	4.7	76.6	9.86	.0428
6	18	9.4	72.7	9.03	.0444
9	20.3	3.1	76.6	10.31	.0356
10	22.8	5.5	71.7	24.22	.0001
15	20.3	3.1	76.6	10.31	.0356
16	13.3	4.7	82	10.87	.0376

Table 7
Summary of Distribution of Items Measuring Learner Preference of Textual Display

Items	Textual Display		
	Simple	Moderate	Complex
Positive			
First	0	11	0
Second	11	0	0
Third	0	0	11
Negative			
First	0	0	6
Second	6	0	0
Third	0	6	0

Title:

The Effects of Organizational Climate Factors on Industrial Training Outcomes

Author:

Rita C. Richey

Foundations of the Study

Theoretical Framework

Winn (1989) has called upon instructional designers to "reason from basic principles of learning and instruction rather than simply following design models" (p.36). This tact requires adherence to a broader, and more intricate, scheme of conceptual considerations than has been incorporated into the typical set of design procedures advocated. It is an approach that demands study of a wide range of variables, such as those which were proposed in a framework for use in the construction of a comprehensive theory of instructional design. The model is conceptual, rather than procedural in nature; it encompasses clusters of variables related to the learner, the content, the delivery, and the environment (Richey, 1986). The validity and utility of such a model, however, are dependent upon data, preferably data which has been replicated in various settings.

The present study highlights the role of environmental factors in the learning process. Such factors have been found to be instrumental in learner achievement in a variety of pre-adult schooling situations (Brookover, et.al. cited in Good and Brophy, 1986; Anderson, 1982; Randhawa and Fu, 1973). Walberg (cited in Randhawa and Fu, 1973) even argues that environmental factors play the most important role in learner achievement next to general aptitude. The research reported here represents an attempt to identify similar effects in adult training situations.

In general, few critical interactions between environment and adult learning have been empirically demonstrated. Cookson (1986) notes that "external context variables have been largely ignored in the adult education literature" (p. 133). In spite of this, many believe in the general proposition that "learning is not just a psychological process that happens in splendid isolation from the world in which the learner lives, but that it is intimately related to that world and affected by it" (Jarvis, 1987, p. 11).

Environment has been described in terms of setting and climate. The settings (with respect to instructional design) are structural, describing varying education and training contexts. In this study the setting was that of industrial training in a large manufacturing company. Climate relates to qualitative variables. Climate can be a function of external influences, physical materials and arrangements, the participant characteristics, and the atmosphere of the organization itself (Richey, 1986). Here, varying types of organizational climate factors are considered.

Research Framework

The general model for this research is shown in Figure 1. This model, basically an input-process-output model, shows multiple outcomes of training. It is a model that includes variables which are hypothesized to influence effectiveness of the instructional design process. It is a model which suggests causal relationships. Finally, it is a model that suggests transfer of training effects.

Training Framework

The training program in this study related to industrial safety -- energy control and power lockout. (ECPL). The topic emerged as a result of previous research and an examination of company accident records. The training was jointly sponsored by a major automobile manufacturer and an automotive union in an effort to change employee attitudes and behaviors in relation to power lockout. Locking out involves shutting down the assembly line while completing diagnosis and/or repair tasks. Failure to lock out has resulted in serious injury and death. The locking out process, however, is expensive since it completely stops production.

The ECPL training program was professionally designed and developed. The instructional materials consisted of:

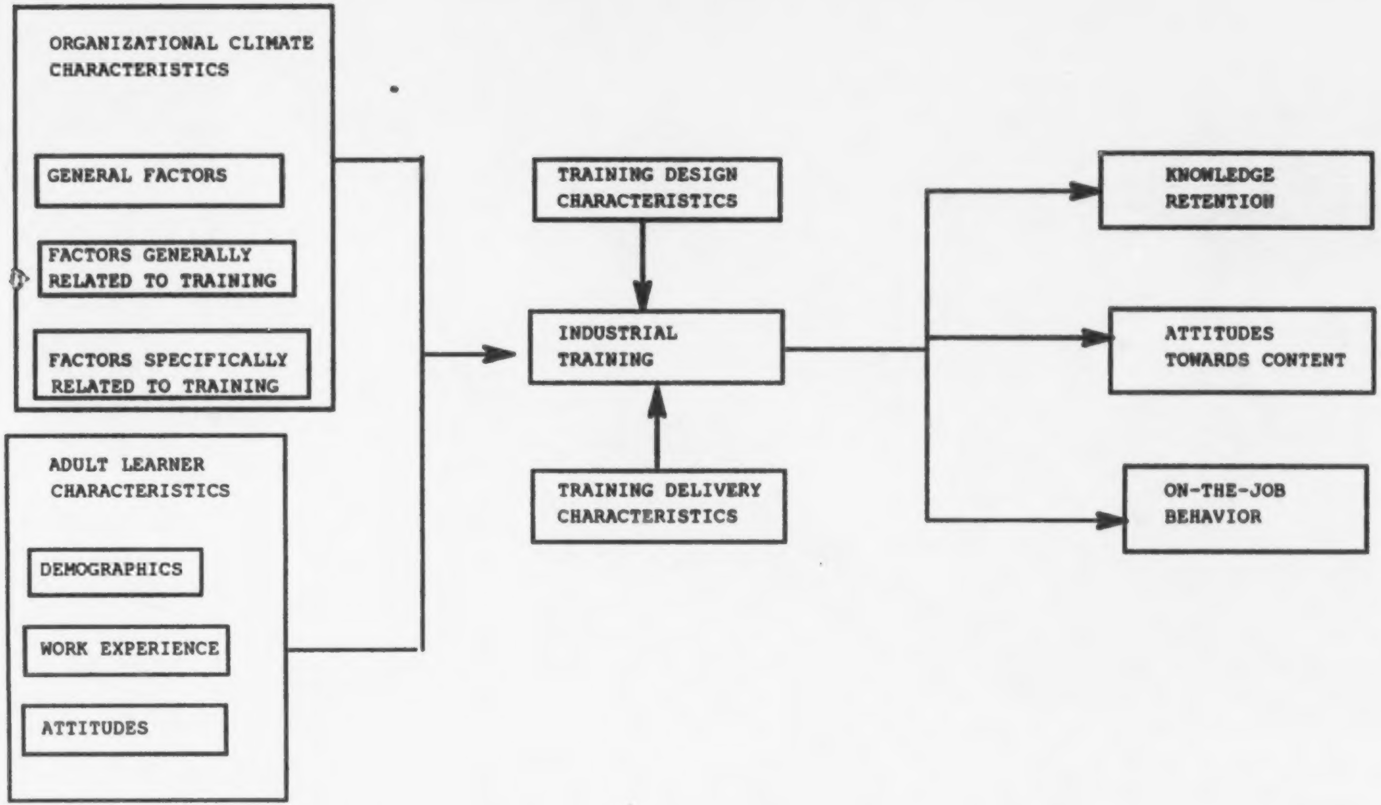
a. eight modules,
b. a videotape,
c. an instructor's manual
d. a participant's workbook, and
e. a portable pocket manual.

The first module in the series was a leadership commitment module for local plants and union management. The remaining seven were directed towards employees who are expected to follow lockout procedures on their jobs. They dealt with behavior change and skill development.

Classes were conducted at each manufacturing plant by nonprofessional trainers with less than 25 persons in a class. The trainers presented the program content, led the discussion, and demonstrated the ECPL procedures. Each training period consisted of seven two hour sessions spanning two work weeks; the courses were repeated in each plant until all participating personnel had attended.

The trainers were salaried and hourly employees whose duties included either lockout or supervision of employees who needed to lock out. The trainers received four days of training to prepare themselves to serve as instructors. They were on temporary assignment until the program was completed.

FIGURE 1
A MODEL OF AN INDUSTRIAL
TRAINING RESEARCH EFFORT


ORGANIZATIONAL CLIMATE CHARACTERISTICS
GENERAL FACTORS
FACTORS GENERALLY RELATED TO TRAINING
FACTORS SPECIFICALLY RELATED TO TRAINING
ADULT LEARNER CHARACTERISTICS
DEMOGRAPHICS
WORK EXPERIENCE
ATTITUDES
TRAINING DESIGN CHARACTERISTICS
INDUSTRIAL TRAINING
TRAINING DELIVERY CHARACTERISTICS
KNOWLEDGE RETENTION
ATTITUDES TOWARDS CONTENT
ON-THE-JOB BEHAVIOR

Procedures

Research Design

Design Summary. The research was conducted within the context of an extensive evaluation of the safety training program. The study was structured as a pre-test and post-test design. Participants completed a questionnaire prior to the training and within 30-90 days after training. Current knowledge, behavior patterns, beliefs and attitudes were determined; in addition, standard demographic data were collected.

Dependent Variables. The research question is one of determining the effects of entry perceptions of organizational climate factors on training outcomes. The training outcomes used are gain scores calculated from the pre- and post-test measures of:

1. Knowledge (based upon performance on a 22 item ECPL content knowledge test),
2. Attitudes towards safety on the job (based upon self-report),
3. On-the-job application of general safety precautions (based upon self-report), and
4. On-the-job application of specific behaviors taught (based upon self-report of recent use of ECPL procedures).

Independent Variables. The organizational climate factors were measured by employee perceptions of 20 different climate elements. These measures were replications, to a great extent, of those used in previous industrial research. The perceptions were measured prior to training. The variables were clustered into four groups:

General Organizational Climate Factors

a. Cooperative working conditions
b. Involvement in decision making
c. Physical working conditions
d. Ratings of overall quality of work
e. Supervisor ratings
f. Encouragement to be innovative
g. Degree to which working conditions promote productivity

Organizational Climate Factors Generally Related to Training

a. Union/company support safety
b. Supervisors quick correction of safety hazards

c. Extent to which management is informed of safety issues
d. Pressure from colleagues to follow safety procedures

Organizational Climate Factors Specifically Related to Training
a. Company/union want workers to lockout
b. Operation more important than lockout
c. Employees accountable for not locking out
d. Physical conditions promote easy lockout
e. Lock availability
f. Frequency of lock use into next shift or longer
g. Employee authority to lockout
h. Work makes lockout impossible
i. Lockout not a common practice

Population and Sample

There were two trainee populations -- hourly personnel, and salaried and supervisory personnel. The samples were selected on a stratified basis. The samples came from five plants representative of the entire company in terms of plant type, size, location in the Metropolitan Detroit area, and previous involvement in research projects. All participating plants were approved by representatives of the union and the company management. There were over 5300 employees in the five selected plants, and a total of approximately 50,000 employees were trained throughout the corporation. The pre-test sample consisted of 389 employees, with 284 of these retained for post-testing.

Simple random selection of trainees was not possible, but random selection of classes was permitted. All classes were randomly formed, and each group consisted of employees from a large number of departments within the plant. The trainee sample represented a broad spectrum of adult learners. Table 1 describes the trainees in the study in terms of sex, race, age, educational level, and employment experience.

Data Analysis

The model shown in Figure 2 provides the initial hypotheses for this study. (The variables in this model are derived from the general research framework presented in Figure 1.) The model suggests that attributes of the general organizational climate determine specific organizational climate characteristics; and, climate, as a whole, effects training outcomes.

Path analysis was used to evaluate and to estimate the dimensions of this model. The technique enables one to estimate the causal influence of a number of variables considered simultaneously. The initial models are formulated on the basis of theoretical expectations and then

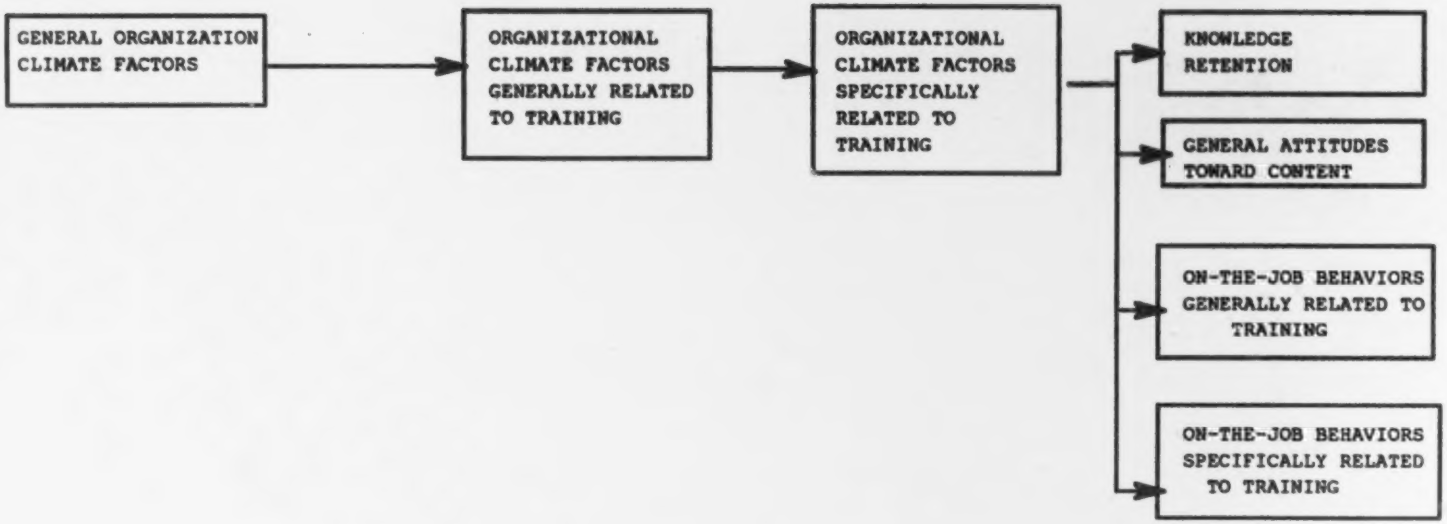
Table 1

A Comparison of Hourly and Salaried ECPL Trainee Characteristics Using Pre-Test Data

Characteristic	Hourly N	Hourly %	Salaried N	Salaried %	Combined N	Combined %
Total Respondents	307	100.0	73	100.0	380	100.0
Sex						
Male	287	93.5	68	93.2	355	93.4
Female	20	6.5	5	6.8	25	6.6
Race						
White	250	80.1	62	19.9	312	80.2
Black	43	81.1	10	18.9	53	13.6
Other	14	93.3	1	6.6	15	3.9
Age						
under 35	66	82.5	13	16.3	80	20.6
36-45	122	79.7	31	20.2	153	39.3
46-55	76	75.2	25	24.8	101	26.0
56 +	46	92.0	4	8.0	50	12.9
Education						
Less Than High School	61	98.4	1	1.6	62	15.9
High School	99	90.8	10	9.2	109	28.0
Trade School/ Some College	133	77.8	38	22.2	171	44.0
College Degree or more	9	26.5	25	73.5	34	8.7
Years on Present Job						
0 - 5	139	79.0	37	21.0	176	45.2
6 - 10	51	89.5	6	10.5	57	14.7
11- 15	36	75.0	12	25.0	48	12.3
16- 20	36	90.0	4	10.0	40	10.3
21	45	75.0	15	25.0	60	15.4
Years at Company						
0 - 5	10	58.8	7	41.2	17	4.4
6 - 10	18	69.2	8	30.8	26	6.7
11- 15	70	84.3	13	15.7	83	21.3
16- 20	74	90.2	8	9.8	82	21.1
21	137	78.3	38	21.7	175	45.0

FIGURE 2

A MODEL OF THE HYPOTHESIZED RELATIONSHIPS
BETWEEN ORGANIZATIONAL CLIMATE VARIABLES
AND TRAINING OUTCOMES


GENERAL ORGANIZATION CLIMATE FACTORS
ORGANIZATIONAL CLIMATE FACTORS GENERALLY RELATED TO TRAINING
ORGANIZATIONAL CLIMATE FACTORS SPECIFICALLY RELATED TO TRAINING
KNOWLEDGE RETENTION
GENERAL ATTITUDES TOWARD CONTENT
ON-THE-JOB BEHAVIORS GENERALLY RELATED TO TRAINING
ON-THE-JOB BEHAVIORS SPECIFICALLY RELATED TO TRAINING

evaluated empirically. McDonald and Elias have recommended the use of path analysis in relating teaching performance data to student achievement, proposing such techniques as tools in building instructional theory (McDonald and Elias, 1976 cited in Gage, 1977).

Results

The results support the general notion that organizational climate variables influence training outcomes. However, only one of the four models constructed yield results that are worthy of extensive comment. This was the model showing the role of organizational climate variables in relation to on-the-job behavior directly related to the training content. The other three models (relating to general on-the-job behavior, attitude change, and knowledge retention) indicate that organizational climate has only a very small role.

A Model Relating Organizational Climate Factors to Specific On-the-Job Behavior After Training

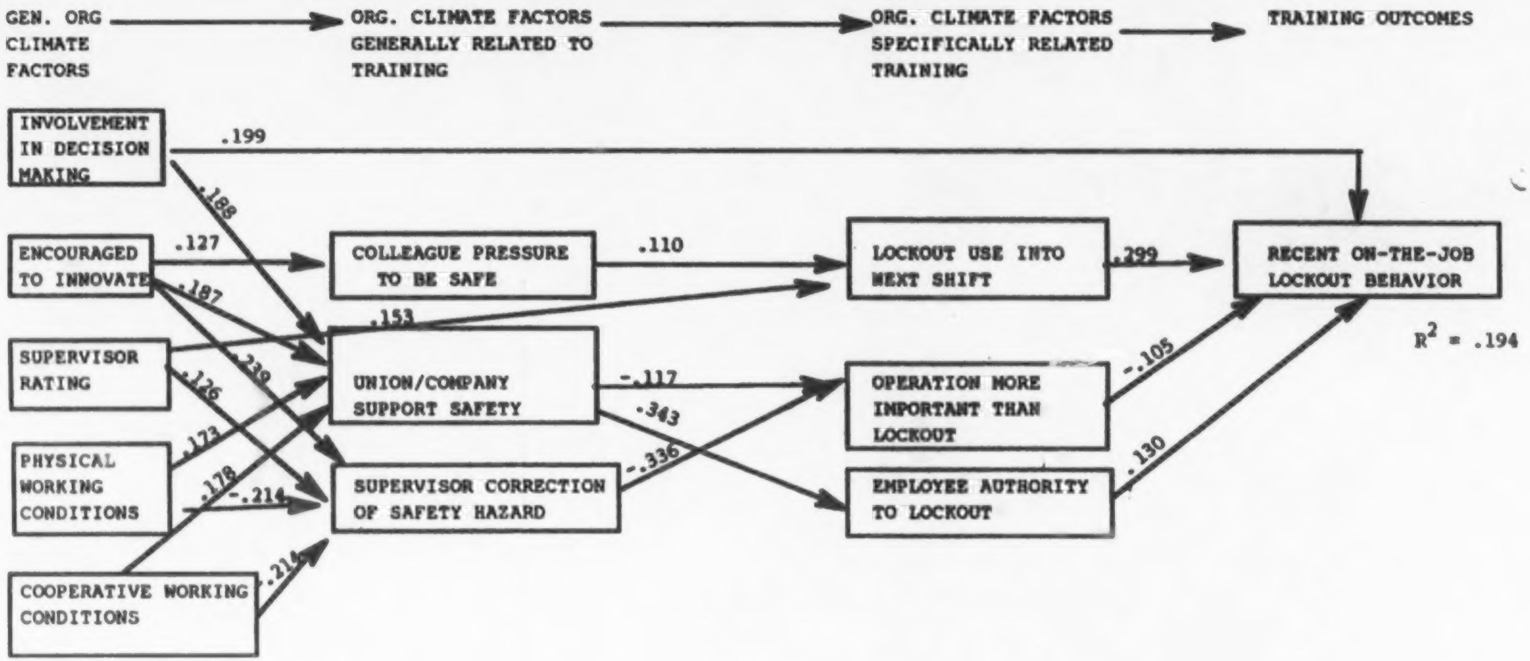
The path diagram shown in Figure 3 is the basis of this discussion. Supporting data is displayed in Table 2.

The model shows a complex network of interrelated organizational climate factors which explain nearly 20% of the variance in the training outcomes; it supports the hypothesized pattern of general factors predicting the more specific factors, with the major effects produced by the most specific climate measures -- those directly related to the training content. The direct causal influences of recent on-the-job lockout behavior relate to employee perceptions of management actions, and to the extent to which employees feel they are empowered to be involved in plant operations. An examination of those variables which have both direct and indirect relationships to training-specific on-the-job behavior not only shows the continued influence of these two types of variables, but also of the influence of colleagues and physical working conditions.

Employee Perceptions of Management Actions. There are five variables in the model related to how the employees perceive management -- lockout use into next shift, operation more important than lockout, union/company support safety, supervisor's quick correction of safety hazards, and the general rating of the supervisor's performance. The first four speak to management credibility when it comes to safety and lockout. Do management actions really demonstrate that supervisors think safety matters?

These variables concerned with management are interrelated. Employees who think supervisors really are more concerned with production "when push comes to shove" are less likely to think the company and the union really support safety and are less likely to think their

FIGURE 3
A MODEL OF THE EFFECTS OF ORGANIZATIONAL CLIMATE FACTORS ON SPECIFIC ON-THE-JOB BEHAVIOR OUTCOMES OF TRAINING*


GEN. ORG CLIMATE FACTORS
ORG. CLIMATE FACTORS GENERALLY RELATED TO TRAINING
ORG. CLIMATE FACTORS SPECIFICALLY RELATED TRAINING
TRAINING OUTCOMES
INVOLVEMENT IN DECISION MAKING
ENCOURAGED TO INNOVATE
SUPERVISOR RATING
PHYSICAL WORKING CONDITIONS
COOPERATIVE WORKING CONDITIONS
COLLEAGUE PRESSURE TO BE SAFE
UNION/COMPANY SUPPORT SAFETY
SUPERVISOR CORRECTION OF SAFETY HAZARD
LOCKOUT USE INTO NEXT SHIFT
OPERATION MORE IMPORTANT THAN LOCKOUT
EMPLOYEE AUTHORITY TO LOCKOUT
RECENT ON-THE-JOB LOCKOUT BEHAVIOR
.199
.188
.127
.187
.153
.239
.126
.173
.178
-.214
.214
.110
-.117
.343
-.336
.299
-.105
.130
R² = .194

*PATH COEFFICIENTS ARE INDICATED ON EACH PATH

Table 2
Hypothesized Organizational Climate Causes of Specific On-The-Job Behavior Outcomes of Training

Endogenous Variable	Causal Variable	B	SE B	T	Prob.
	Constant	3.105	.249		
Lockout Use Into Next Shift	Supv. Rating	.196	.064	3.052	.002
	Colleague Pressure to be Safe	.188	.086	2.202	.028
Mean = 3.977 SD = 1.740	R Square = .38		N = 389		
	Constant	4.156	.175		
Operation More Important Than Lockout	Supv. Correction of Safety Hazards	-.421	.065	-6.434	.000+
	Union/Company Support Safety	-.156	.070	-2.244	.025
Mean = 2.771 SD = 1.080	R Square = .117		N = 389		
	Constant	1.206	.106		
Employee Authority To Lockout	Union/Company Support Lockout	.341	.048	7.178	.000+
Mean = 1.874 S.D. = 1.080	R Square = .117		N = 389		
	Constant	1.999	.101		
Colleague Pressure To Be Safe	Encouraged To Innovate	.093	.037	2.514	.012
Mean = 2.219 S.D. = 1.018	R Square = .016		N = 389		

Table 2 Cont.

Endogenous Variable Prob	Casual Variable	B	SE B	T	
	Constant	1.145	.122		
	Involvement in Decision Making	.133	.041	3.231	.001
Union/Company Support Safety	Encouraged to Innovate	.146	.051	2.867	.004
	Physical Working Conditions	.134	.048	2.812	.005
	Cooperative Working Conditions	-.099	.050	-1.985	.048
Mean = 1.959 SD = 1.086	R Square = .160		N = 389		
	Constant	1.892	.133		
	Encouraged to Innovate	.198	.052	3.787	.000+
Supervisor Correction of Safety Hazards	Physical Working Conditions	.147	.051	2.878	.004
	Cooperative Working Conditions	-.194	.056	-3.454	.000+
	Supervisor Ratings	.107	.049	2.194	.029
Mean = 2.563 SD = 1.157	R Square = .125		N = 389		

Table 2 Cont.

Dependent Variable	Casual Variable	B	SE B	T	Prob
Gains in Recent Job Lockout Behavior	Constant	1.923	.546		
	Lockout Use Into Next Shift	.462	.084	5.500	.000+
	Involvement in Decision Making	.346	.096	3.591	.000+
	Employee Authority to Lockout	.323	.137	2.354	.019
	Operation More Important than Lockout	-.194	.101	-1.925	.055

Mean = .884
SD = 2.684 R Square = .194 N = 284

supervisors correct safety hazards when they are pointed out. Correspondingly, a belief that there is general support of safety relates to the belief that employees are given the authority to lockout.

The fifth significant variable in this category is a more general rating of the supervisor. This is the only measure in this grouping not related to the topic of the training; but, this partially explains two of the other more training-specific measures in this group -- lockout use into the next shift and supervisor correction of safety hazards. Supervisors received higher ratings if employees felt that the supervisors 1) quickly corrected hazards which were brought to their attention, and 2) shut down production -- for a long time, if necessary -- by locking out to insure safety.

Employee Empowerment. The next most influential group of variables related to the extent to which employees were given rights and responsibilities. These factors were the extent to which trainees felt they had the authority and responsibility to lockout, were involved in decision making in the plant, and were encouraged to devise new and better ways of doing things in the plant. Two of the three factors are general climate issues, not related to the training content. The importance of this group of variables is shown by the fact that two of the three measures in the group directly influence employee lockout behavior.

Collegial Relationships. Variables relating to the influence of other workers also play a role in this model. If workers not following safe practices generally irritate others, even if no one gets hurt, there is a tendency for supervisors to permit use of lockout techniques into the next shift.

The effects of a general cooperative atmosphere among workers shows a different pattern; these data show increased collegiality relates to a more negative perception of supervisors' safety attitudes and behaviors. This finding is difficult to explain. Perhaps there is a bonding among workers which leads to increased cooperation when employees feel there is not a genuine support of safety in the plant.

Physical Working Conditions. Finally, the degree of satisfaction one has with the physical working conditions does have an indirect role in predicting on-the-job behaviors effects of training. Better physical conditions, as might be expected, predict more positive perceptions of climate factors generally related to the training content.

Other Models of Organizational Climate Influences on Training Outcomes

The data analyses with respect to the other dependent variables -- general on-the-job behavior outcomes, general attitude outcomes, and knowledge retention -- also show that organizational climate variables play a role in explaining training outcomes; however, it is so small that little discussion is warranted. (See Figures 4, 5, and 6 and the supporting data in Tables 3, 4, and 5 in Appendix A.) Next to specific behavioral outcomes, organizational climate factors seem to have the most influence on general attitude changes, accounting for nearly eight per cent of the variance. There are negligible effects in the other models.

Perhaps one result that should be noted is that the climate variables specifically related to training tend to disappear when the training outcome being considered is general in nature.

Conclusions

The major conclusion of this study is that if one is intent on designing an effective industrial training program, consideration needs to be given to more than systematic procedures for designing programs, materials and media. One must consider all factors that affect the learning process. In an adult industrial training program, in particular, where the goal is not simply knowledge acquisition, but knowledge application, dimensions of the larger system must be taken in account.

On-the-job application of training content involves elements of transfer of training, elements of motivation, and elements of information retrieval. What is the nature of the role of organizational climate in all of these processes? Inherent in one's perception of an organization is the picture of the extent to which the organization (both colleagues and supervisory personnel) value the behaviors which are being promoted. These values are typically inferred through daily performance, or modeling. Another major factor suggested by the results of the present study is the perceived influence of the individual within the organization. Both modeling and perceived influence appear to have a substantial bearing on the application of training content. The physical working conditions have far less impact on behavior changes which occur after a systematic training experience.

Behavior Modeling Effects

Killen and Robinson (1988) have cited the major influence of "social-environmental modeling" (p. 175), especially in situations related to health behaviors. Their conclusions were based primarily on research relating to children; the present study suggests that modeling is important for adults, as well. Transfer of knowledge to workplace practice was clearly promoted by general adherence to safety principles by both colleagues and supervisory personnel, as well as specific demonstration of lockout procedures by supervisors. Overall, the most influence comes from supervisors rather than co-workers.

These behavior patterns are consistent with The Health Belief Model which explains health behavior in terms of

one's perceptions of 1) the severity of a condition, 2) the benefits of the preventive action minus the barriers to the action, and 3) the presence of action cues (Maiman and Becker, 1974, as cited in Murphy, 1989). Each of these characteristics can be explained in terms of modeling behaviors within the organization, but especially by management. If one's supervisor locks out, the message is sent that the lockout benefits are greater than the inconveniences it causes. Seeing one's supervisor lock out may also serve as a reminder, a cue to action.
Modeling behaviors among co-workers are also important, since they create a climate in which the supervisors tend to enforce the lockout procedures (n.b. "colleague pressure to be safe" leads to "lockout use into next shift").

Role of the Individual within the Organization

The mere presence of model behavior is insufficient in itself to promote on-the-job application of the training content. The modeling provides external stimulation to apply the content of the training, but the trainee must also perceive that he or she has a role of some influence in plant operations. These attitudes apparently provide at least part of the internal motivation necessary to follow the prescribed safety procedures. Such results are interesting in light of the energies being placed upon employee involvement and union-management cooperation in many companies as an avenue towards improved production quality.

Health and safety topics often involve behavior in which knowledge of correct procedures is not the issue. Rather, the problem is one of forming habits of known procedures. Even when survival issues are at stake (i.e. serious injury), habits are not forthcoming without internal beliefs that provide a motivating basis for action. The present study supports this conclusion; there was a correlation between a number of attitudinal factors and on-the-job behavior, but not between knowledge of procedures and their use. (Knowledge retention showed no correlation in the preliminary analysis with the on-the-job behavior dependent variable and was dropped from the model.)

Stimulating New On-the-Job Behavior

Industrial safety behavior changes, therefore, seem influenced not so much by knowledge but by a climate in which supervisors and co-workers value the desired actions and by the perceptions that employees are valued themselves in the organization. As previously noted, the Health Belief Model also indicates the need for a cue to action; the modeling behavior of others was suggested as a possible environmental stimulus. Other situations can also serve this function. For example, if an employee is injured on the job, this could also serve as a cue to action. The cues can be planned. In the context of this study, posters were placed in the plants as reminders to lock out.

The need for specific action stimuli is also supported by previous research and theory of human information processing and transfer of training. Some cue is required to facilitate information retrieval. The cue is typically embedded in the instruction, and consequently one's long-term memory. Reminders are needed to retrieve the knowledge, in this instance the lockout procedures, and use it in the proper manner. Repetition of this retrieval-use process then promotes automaticity, or habit. Such habits, however, are dependent first on having the correct information stored and working in an environment which is supportive of attending to the cue.

Implications for Instructional Design

Well-designed materials, courses, and programs influence knowledge acquisition and retention. If knowledge is only an intermediate goal and the ultimate aim is to change behavior, then the designer must be guided by a model more complex than the typical instructional systems design framework. The new model must encompass the nature of the organization in which the behaviors are to be exhibited. This present study suggests that the more important organizational characteristics relate to social-psychological dimensions rather than physical properties.

Design procedures should be expanded, as well. Specifically, this study has implications for design aspects such as the needs assessment, the types of examples incorporated into instructional materials, and the follow-up. The most useful needs assessment should include more than trainee needs and organizational technical needs. Employee perceptions of the work environment and their roles within that context should be determined. Instructional materials should be constructed to include those cues which one expects to stimulate the desired performances. For example, in this case videos could emphasize the average worker locking out, and include situations in which lockout is enforced by the supervisor and plant management. These cues are obvious; however, other cues could also be identified and portrayed.

Finally, designers can make efforts to promote organizational support of the desired behavior. They can recommend that supervisors and plant management be included in the training, and suggest periodic follow-up instruction for everyone. In addition, follow-up studies should assess not only the continued use of the training content, but the organizational climate most directly related to the training. In summary, these suggestions provide support for the integration of both the cognitive and affective domains into complex instructional sequences, thus supporting the work of Martin and Briggs (1986).

Implications for Adult Learning

The findings of this study speak not only to design practice, but also to principles of adult learning, and how it differs from learning of pre-adults. Adult learning is usually work-related. The National Center for Education Statistics found that almost 49% of adult education content in the United States is concerned with one's work (cited in Darkenwald and Merriam, 1982). This present study indicates that one's perceptions of his or her workplace accounts for almost 20 percent of the variance in the behavioral effects of work-related training. This is reminiscent of Bloom's (1976) finding from studies of children that "affect toward the school... will account for as much as 20 percent of the variation in school achievement" (p. 92).

Bloom's findings were minimal in relation to children in grades 1-5 and more pronounced for subjects in junior and senior high school. He concludes that attitudes towards school become more influential as one's experience in the school setting increases. At the adult level, the perceptions of one's environment continue to be influential.

Bloom's pre-adult findings and the adult findings in this study differ in the nature of the dependent variable. Bloom's findings concern cognitive academic achievement reflected in grade point averages and composite scores on achievement tests, measures generally comparable to the knowledge retention scores in this study. Here the organizational climate variables are influential primarily in relation to on-the-job behavior, an indication of transfer of training.

For adults, the transfer task seems to encompass a wider range of predictor variables than the knowledge recall task. While transfer of training is viewed primarily from the theory of common elements (Butterfield and Nelson, 1989), this study proposes the addition of other factors in explaining the transfer process. The organizational climate factors seem to provide a motivation to use the learned procedures. Transfer appears to be dependent upon not only capability, but inclination.

Summary and Next Steps

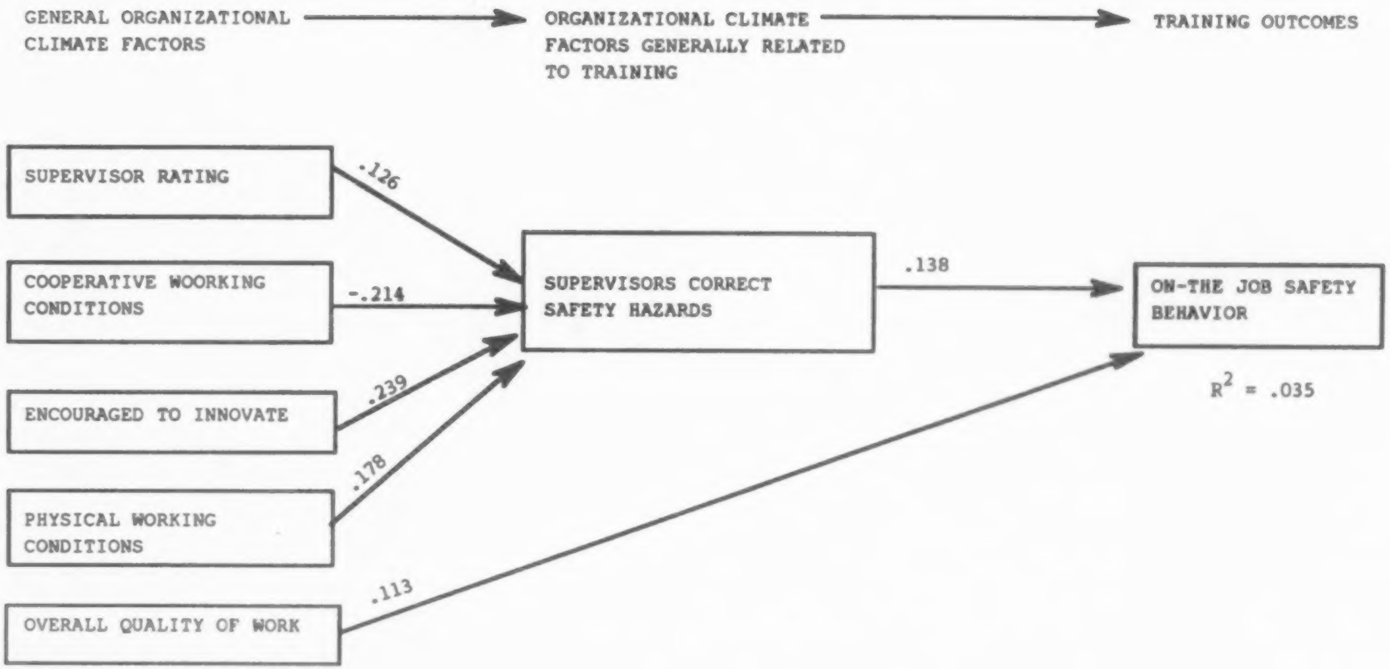
Organizational climate and its role in adult learning is often discussed, but the discussions have produced little data to support opinions. This study has identified a role organizational climate plays in industrial training; it is not known if the pattern is consistent for other adult learning situations, both formal and informal. Not only could the setting in this study produce unique findings, but the findings may be influenced by the fact that the study was concerned with required training on a topic with high risk implications. The population involved, however, was a comprehensive group with a broad range of demographic characteristics; it was not an exceptional group of adults.

Not only should studies of organizational climate be repeated in other settings, but climate effects should be studied in relation to critical learner characteristics. The measures here were all employee perceptions. Such attitudes may vary for different age cohorts, or for persons with different experiential backgrounds, for example. Organizational climate perceptions may also be dependent upon the employee's job satisfaction. This latter issue leads a researcher into considering the interrelations between various types of attitudes, and their effects on the learning process.

Ultimately, the question arises as to the extent instructional design interventions can effect the influence of organizational climate perceptions on the learning process. Superior design can counteract, to a certain degree, the effects of many adult learner characteristics -- age, ability, and interest for example. Once, the full role of organizational climate is known, do we simply adjust to its effects, or can we modify the instruction to remove climate-induced barriers to learning and transfer of training?

APPENDIX A

Figure 4
A MODEL OF THE EFFECTS OF ORGANIZATIONAL CLIMATE FACTORS
ON GENERAL ON-THE JOB BEHAVIOR OUTCOMES OF TRAINING *


GENERAL ORGANIZATIONAL CLIMATE FACTORS
ORGANIZATIONAL CLIMATE FACTORS GENERALLY RELATED TO TRAINING
TRAINING OUTCOMES
SUPERVISOR RATING
.126
COOPERATIVE WOORKING CONDITIONS
-.214
ENCOURAGED TO INNOVATE
.239
PHYSICAL WORKING CONDITIONS
.178
OVERALL QUALITY OF WORK
.113
SUPERVISORS CORRECT SAFETY HAZARDS
.138
ON-THE JOB SAFETY BEHAVIOR
R2 = .035

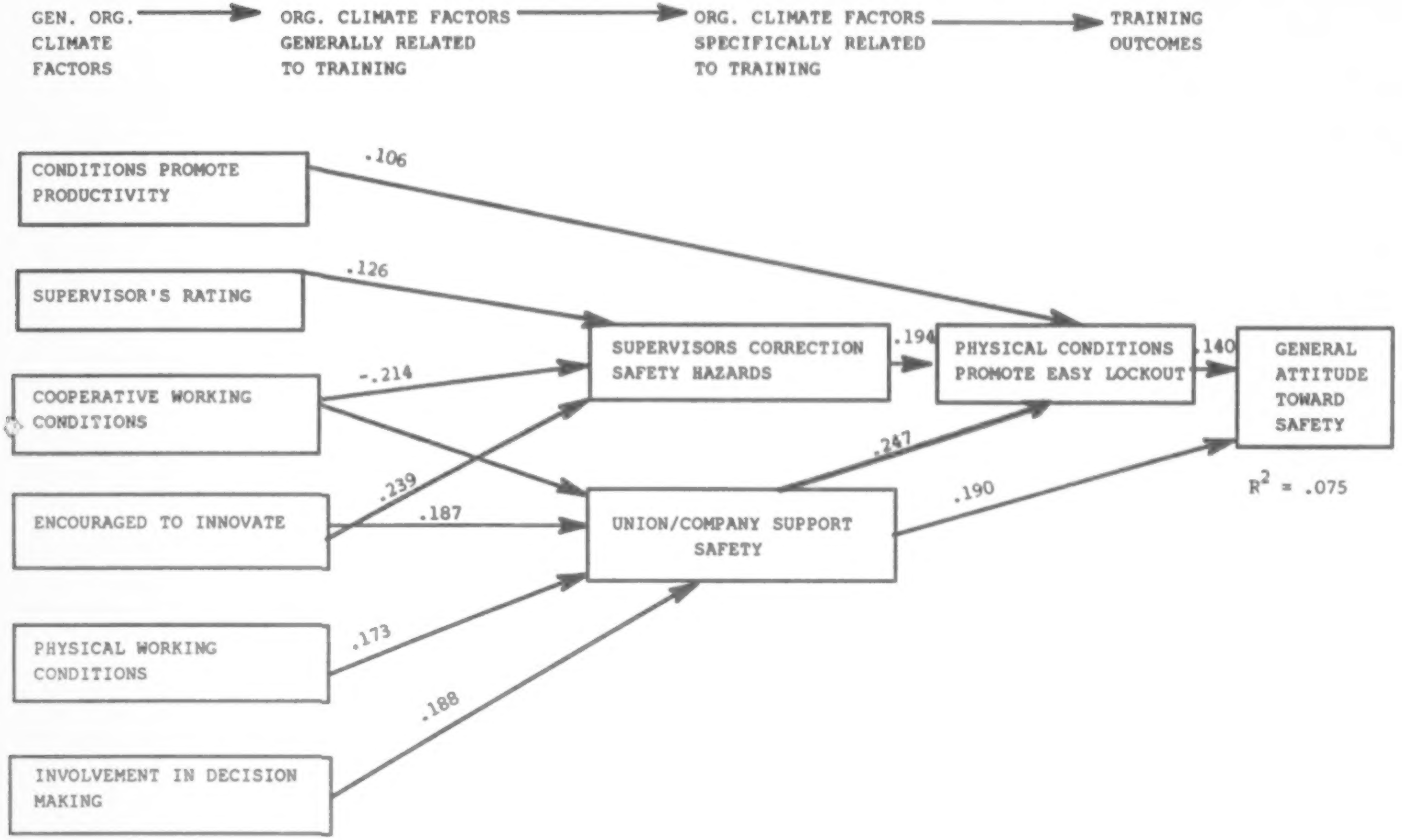
*PATH COEFFICIENTS ARE INDICATED ON EACH PATH

Table 3
Hypothesized Organizational Climate Causes of General On-The-Job Behavior Outcomes of Training

Endogenous Variable	Casual Variable	B	SE B	T	Prob
Supervisor Correction of Safety Hazards	Constant	1.892	.133		
	Encouraged to Innovate	.198	.052	3.787	.000+
	Physical Working Conditions	.147	.051	2.878	.004
	Cooperative Working Cond.	-.194	.056	-3.454	.000+
	Supervisor Rating	.107	.049	2.194	.029
Mean = 2.563 SD = 1.157		R Square = .125	N = 389		

Dependent Variable	Casual Variable	B	SE B	T	Prob
Gains in On-the-job Safety Behavior	Constant	.445	.267		
	Supervisor Correction of Safety Hazards	.202	.087	2.336	.020
	Overall Quality of Work	.139	.073	1.911	.057
Mean = .356 SD = 1.701		R Square = .035	N = 284		

FIGURE 5
A MODEL OF THE EFFECTS OF ORGANIZATIONAL CLIMATE FACTORS ON GENERAL ATTITUDINAL OUTCOMES OF TRAINING *


GEN. ORG. CLIMATE FACTORS
ORG. CLIMATE FACTORS GENERALLY RELATED TO TRAINING
ORG. CLIMATE FACTORS SPECIFICALLY RELATED TO TRAINING
TRAINING OUTCOMES
CONDITIONS PROMOTE PRODUCTIVITY
SUPERVISOR'S RATING
COOPERATIVE WORKING CONDITIONS
ENCOURAGED TO INNOVATE
PHYSICAL WORKING CONDITIONS
INVOLVEMENT IN DECISION MAKING
SUPERVISORS CORRECTION SAFETY HAZARDS
UNION/COMPANY SUPPORT SAFETY
PHYSICAL CONDITIONS PROMOTE EASY LOCKOUT
GENERAL ATTITUDE TOWARD SAFETY
.106
.126
-.214
.239
.187
.173
.188
.194
.247
.140
.190
R² = .075

* PATH COEFFICIENTS ARE INDICATED ON EACH PATH

Table 4
Hypothesized Organizational Climate Causes
of General Attitudinal Outcomes of Training

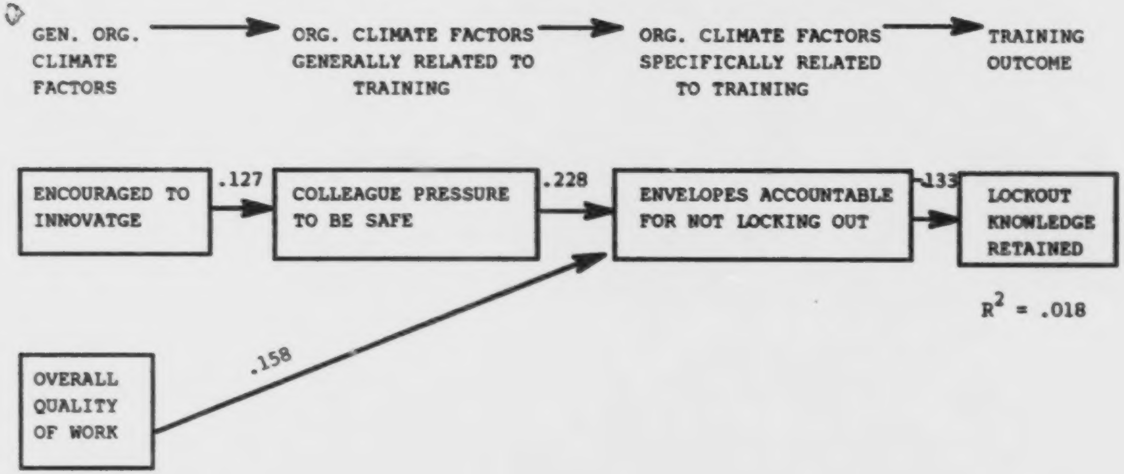
Endogenous Variable	Casual Variable	B	SE B	T	Prob
Physical Conditions Promote Easy Lockout	Constant	1.124	.138		
	Union/Company Support Safety	.233	.050	4.681	.000+
	Supervisors Correction of Safety Hazard	.172	.046	3.722	.000+
	Conditions Promote Productivity	.077	.035	2.228	.026
Mean = 2.213 SD = 1.025	R Square = .171		n = 389		
Supervisor Correction of Safety Hazards	Constant	1.892	.133		
	Encouraged to Innovate	.198	.052	3.787	.000+
	Physical Working Conditions	.147	.051	3.878	.004
	Cooperative Working Conditions	-.194	.056	-3.454	.000+
	Supervisor Rating	.107	.049	2.194	.029
Mean = 2.563 SD = 1.157	R Square = .125		N = 389		

Table 4 Cont.

Endogenous Variable	Casual Variable	B	SE B	T	Prob
	Constant	1.145	.122		
Union/Company Support Safety	Involvement in Decision Making	.133	.041	3.231	.001
	Encouraged to Innovate	.146	.051	2.867	.004
	Physical Working Conditions	.134	.048	2.812	.005
	Cooperative Working Conditions	-.099	.050	-1.985	.048
Mean = 1.959 SD = 1.086	R Square = .160		N =389		

Dependent Variable	Casual Variable	B	SE B	T	Prob
	Constant	.577	.155		
Gains in General Attitudes Toward Safety	Union/Company Support Safety	.184	.060	3.089	.002
	Physical Conditions Promote Easy Lockout	.144	.063	2.275	.024
Mean = .102 SD = 1.053	R Square = .075		N = 284		

FIGURE 6
A MODEL OF THE EFFECTS OF ORGANIZATIONAL CLIMATE FACTORS ON KNOWLEDGE RETANTION OUTCOMES OF TRAINING


GEN. ORG. CLIMATE FACTORS
ORG. CLIMATE FACTORS GENERALLY RELATED TO TRAINING
ORG. CLIMATE FACTORS SPECIFICALLY RELATED TO TRAINING
TRAINING OUTCOME
ENCOURAGED TO INNOVATGE
.127
COLLEAGUE PRESSURE TO BE SAFE
.228
ENVELOPES ACCOUNTABLE FOR NOT LOCKING OUT
-133
LOCKOUT KNOWLEDGE RETAINED
R2 = .018
OVERALL QUALITY OF WORK
.158

*PATH COEFFICIENTS ARE INDICATED ON EACH PATH

Table 5
Hypothesized Organizational Climate
Causes of Knowledge Retained After Training

Endogenous Variable	Casual Variable	B	SE B	T	Prob
	Constant	1.342	.142		
Employees Accountable for Not Locking Out	Colleague Pressure to be Safe	.237	.051	4.662	.000+
	Overall Quality Of Work	.121	.037	3.241	.001
Mean = 2.116 SD = 1.060	R Square = .081		N =389		
	Constant	1.999	.101		
Colleague Pressure to be Safe	Encouraged to Innovate	.093	.037	2.514	.012
Mean = 2.219 SD = 1.018	R Square = .016		n = 389		

Dependent Variable	Causal Variable	B	SE B	T	Prob.
	Constant	1.502	.473		
Gains in Lockout Knowledge Retained	Employee Accoutable for Not Locking out	.463	.206	2.254	.025
Mean = 2.482 SD = 3.691	R Square = .018		N = 284		

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Title:

Effects of Animated Visuals on Incidental Learning and Motivation

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Effects of Animated Visuals on Incidental Learning and Motivation

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Abstract

The effects of animated presentations on intentional and incidental learning was studied. Also studied was the degree to which computer practice activities contained intrinsically motivating characteristics as measured by continuing motivation. A total of 70 fourth graders participated in an introductory lesson on Newton's Laws of Motion. Two levels of Visual Presentation (Static Graphic, Animated Graphic) were crossed with two levels of Practice Order (Questions/Simulation, Simulation/Questions). Within-subjects factors consisted of Learning Intent (Intentional, Incidental), Visual Testing Format (All Verbal, Verbal/Visual), and Test Interval (Immediate, Delayed). Results showed that Animated Graphics successfully promoted incidental learning. In addition, students overwhelmingly chose to return to the structured simulation practice when placed in a free-choice situation.

Recent advances in authoring computer-based instruction (CBI) have provided designers with relatively easy means of adding diverse and elaborative features to instructional software. Features which once demanded advanced programming skills and liberal development timelines can now be almost casually incorporated. Animation has long been a popular feature in CBI, and its use, along with other types of graphics, is often encouraged (Bork, 1981; Caldwell, 1980). Unfortunately, animation is frequently added to CBI without serious concern for its true instructional purpose or impact.

Instructional research has focused on two fundamental applications of animation in CBI: 1) animation as a presentation strategy; and 2) practice activities involving interactive animated graphics. Recent reports have offered encouraging results for both applications (Rieber, in press-b; Rieber, Boyce, & Assad, in press). General theoretical support of animated visuals is provided by the dual-coding hypothesis (Paivio, 1986) which suggests that highly visual, concrete information is stored both verbally and visually. Retention can be enhanced by external pictures if they promote the activation of dual-coding. When information is dual-coded, the probability of retrieval is increased since if one memory trace is lost, another is still available (Kobayashi, 1986). Efficacy of animated presentations appears particularly dependent on task requirements, cognitive load, and attention-gaining devices. In addition to gains on intentional learning, Rieber (in press-b) reported initial evidence of animation's role in contributing to incidental learning. Elementary school students demonstrated modest success in attending to incidental information contained in a single animated display. A need exists to validate this preliminary finding and investigate its implications further.

The study of incidental learning is well established (Ackerman, 1985; Goldberg, 1974; Klauer, 1984; Lane, 1980; Sagaria & Di Vesta, 1978). Past research has primarily focused on interactions between text processing activities, such as pre- and post-questions, and intentional and incidental learning. The search for true "mathemagenic" activities, or activities which give "birth" to learning in general (Rothkopf, 1966), has led researchers to understand that most instructional activities incur tradeoffs between intentional and incidental learning — contributions to one generally impede the other. Most of this research has concentrated on learning from prose, although several imagery studies have been reported which indicate that recall of incidental information is more robust for pictures than for words (Ghatala & Levin, 1981). Traditional CBI design, based on systems approaches (see Reigeluth, 1983 for a review), has only been concerned with intentional learning, that is, the extent to which predetermined learning objectives have been mastered. Unfortunately, this approach can also lead to instructional designs which are unnecessarily self-limiting and restricting and which are apt to assign a passive role to the learner. The ability of the learner to elaborate upon instruction as well as induce rules and principles not intentionally taught is usually overlooked or ignored. The first objective of this study was to investigate whether students would be able attend to incidental information contained in animated visuals and induce a resulting physical science principle from this information without sacrificing intentional learning.

Previous research has demonstrated that animated presentations interact with the practice activities provided in CBI. Traditional CBI has used questioning strategies as successful practice activities (eg. Hannafin, Phillips, & Tripp, 1986). Rieber (in press-b) and Rieber, Boyce, and Assad (in press) compared the effects of questioning strategies to structured simulations as practice activities in science instruction. The structured simulations consisted of animated graphics which obeyed the laws of motion and were under student control. Brown (1983) has termed these applications of animated graphics as "interactive dynamics". The graphics change continuously over time depending on student input, thus acting as a form of instantaneous feedback (Reed, 1985). Adult performance compared equally with both forms of practice, while elementary school children performed best given the experiences with the interactive dynamics. It is speculated that the success of the interactive dynamics with children was due in part to the apparent intrinsic motivational appeal of the simulation — students were encouraged to fantasize about being the pilot of a starship in outerspace. Intrinsically motivating instruction relies on student-driven strategies, rather than external lesson reinforcement (Lepper, 1985; Malone, 1981). Theories concerning intrinsically motivating instruction are based on motivation research which suggests that students who see themselves in control of their success are destined to stay-on task longer in more meaningful ways and are more likely to return to the instructional task given the freedom to choose (Malone, 1981; Rotter, 1954; Weiner, 1979). The second objective of this study was to validate whether or not these structured computer simulations hold intrinsically motivating characteristics for children. Measures of continuing motivation, such as choosing to return to an instructional task in a free-choice situation, have been used successfully to estimate the construct of intrinsic motivation (eg. Kinzie & Sullivan, 1989). Continuing motivation can be defined as an individual's willingness to return to an activity once external pressure to do so has ceased (Maehr, 1976).

There were two purposes to this study: 1) to investigate the effects of computer animated presentations on intentional and incidental learning; 2) to investigate the locus of motivation to participate in computer-based practice activities. It was hypothesized that students given lessons containing animated presentations would significantly outperform other students on measures of incidental learning. It was also hypothesized that students would choose to return to practice activities involving interactive dynamics more often than other computer practice activities or even other high-interest, non-lesson activities, such as paper puzzles.

Methods

Subjects

The subjects consisted of 70 fourth grade students from an urban public elementary school. Participation was voluntary with selection based on parent consent.

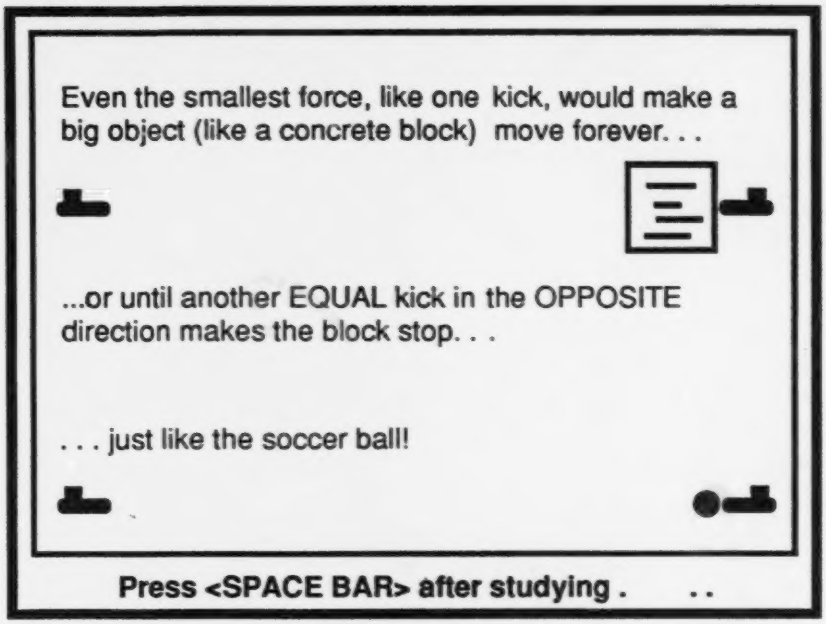
CBI Lesson Content

The CBI lesson, first developed for previous studies (Rieber, in press-a, in press-b; Rieber & Hannafin, 1988) but modified for this study, described and explained Newton's laws of motion. The lesson was divided into two parts. Part one introduced students to Isaac Newton and his first law of motion. Part two provided applications of Newton's first law and an initial application of Newton's second law where mass is held constant and forces vary. All information was presented at an introductory level in the context of one-dimensional motion.

Lesson Versions

Two levels of Visual Presentation (Static Graphic, Animated Graphic) were crossed with two levels of Practice Order (Questions/Simulation, Simulation/Questions).

Visual Presentation. In each Visual Presentation condition the lesson narrative was supplemented with either static or animated graphics. In the Static Graphics condition, forces were represented by a foot giving an object a kick, such as a ball or a concrete block.



Even the smallest force, like one kick, would make a big object (like a concrete block) move forever. . .

...or until another EQUAL kick in the OPPOSITE direction makes the block stop. . .

. . . just like the soccer ball!

Press <SPACE BAR> after studying . . .

FIGURE 1. *Example of a computer screen which used animation to present intentional and incidental information. The "concrete block" and the "ball" were both kicked once. The animation depicted the ball's speed as dramatically greater than that of the block.*

Motion and trajectory attributes were represented by arrows and path lines. The Animated Graphics condition also used the ball, block and foot symbols, however the object was then animated to show the motion and trajectory resulting from the force applied to it. Both types of visuals elaborated the textual information. However, another application of Newton's second law was incidentally demonstrated in the Animated Graphics condition. This law predicts that when two objects of different masses are both acted on by the same size force, the acceleration experienced by the object with larger mass is less. The computer animated a large solid box moving very slowly across the computer screen after being kicked with the same size force which had just been applied to a small animated ball, similar to what is illustrated in Figure 1. No attempt was made to teach or explain why the box moved more slowly than the ball.

Practice Order. Each level of Practice Order consisted of giving all students two types of practice activities, but in different order. The first practice activity consisted of multiple-choice questions. The questions covered the relevant material in the respective lesson part. Feedback was provided to the students in the form of knowledge of correct results. The second practice activity involved the student in a structured simulation. Students were given increasing levels of control over a simulated, free-floating object called a "starship" in the lesson. This structured simulation, an application of the dynaturtle microworld developed by diSessa (1982) and White (1984), had been shown to positively affect lesson performance in prior research with children of this age (Rieber, in press-b). Students participated in the practice activities in the respective order (Questions/ Simulation or Simulation/Questions) after each of the two lesson parts. It was important that all students have equal opportunities to experience both forms of practice so that interpretation of the free-choice data would be valid. However, it was anticipated that the first activity might orient students to the second activity, thus resulting in different success patterns for each activity. This could affect the motivating appeal for each activity. Therefore, Practice Order was added to the experimental design to prevent this from confounding the study. It was not the intention of this experiment to study the performance effects of each practice activity, as this has been adequately demonstrated elsewhere (e.g. Rieber, in press-b).

Dependent Measures

Posttest. The 24-item posttest measured two types of rule learning: intentional and incidental. Intentional learning is defined as learning those objectives which were directly taught in the lesson through the combination of verbal (text) and visual means. Incidental learning is defined as learning those objectives which were not directly taught, but only implied through contextual cues provided in several of the animated visual displays. The posttest was administered twice: first, in two parts immediately upon completion of the relevant lesson parts, and then again approximately two days later in whole as a measure of learning decay/ durability. The use of visuals in the testing was also controlled. Half of the intentional and incidental questions were presented in an all-verbal form and half contained accompanying visuals. Two questions were added to the final administration of the posttest which tested a simple application of Newton's Law of Gravitation. This objective was not taught in any form during the lesson. However, it was anticipated that the animated visuals might promote the misconception that two objects of different masses would fall at different speeds when dropped to the earth. These two questions provided a preliminary measurement of whether such a misconception was actually formed by students.

KR-20 reliability of all 50 questions was .93. Respective reliability coefficients and number of questions for each of the subscales were as follows: .87, 24 (Immediate); .87, 24 (Delayed); .91, 28 (Intentional); .95, 20 (Incidental); .91, 26 (Verbal); .85, 22 (Visual); .64, 2 (Law of Gravitation).

Response Latency. The time required by students to process each of the posttest questions was collected. Processing time is measured as the time (in seconds) taken by students to press the appropriate key once prompted to do so. This variable provides an important indirect measure of the organization strength of initial encoding as evidenced by retrieval time.

Continuing Motivation. Immediately after completing the second administration of the posttest on the fourth day, students were given three choices: 1) answer more practice questions just for fun; 2) spend more time in the structured simulation; or 3) complete a word-find puzzle on another topic. Students were told that they could switch between activities if they wished to do so. Continuing motivation of the practice activities was measured by first choice frequencies of these two options as compared to the first choice frequency of the puzzle activity.

Procedures

All instruction and testing was administered by computer over the span of four, 30 minute computer sessions. The first session acted as a general orientation to familiarize students to the materials and nature of the project. The second session presented lesson part one, followed by practice and then 12 posttest questions relevant to that part. The third session presented lesson part two, followed by practice and then 12 posttest questions relevant to part two. The fourth session involved a re-administration of the original 24 posttest questions and 2 additional questions which measured Newton's law of gravitation. As already indicated, these two questions were added as a preliminary measure of whether the animated graphics promoted misconceptions. After the posttest, students were given the choice to work on either of the two computer-based practice activities (questions or simulation) or an irrelevant, though highly motivating activity consisting of a word-find puzzle. Each session lasted approximately 30 minutes amounting to about 120 minutes of learner time over the course of about 10 days. Students were randomly assigned to one of the treatment groups as they arrived at the computer lab for the first session. Once instructed to begin at the start of each session, students completed the lesson individually under controlled conditions.

Design

In this study a 2 X 2 X (2 X 2 X 2) factorial design was used. Two between-subjects factors levels (Visual Presentation, Practice Order) were crossed with three within-subjects factors (Learning Intent, Visual Testing Format, Test Time). The between-subjects factors consisted of two levels of Visual Presentation (Static Graphic, Animated Graphic) and two levels of Practice Order (Questions/Simulation, Simulation/ Questions). The within-subjects factors consisted of two levels of Learning Intent (Intentional, Incidental), two levels of Visual Testing Format (All Verbal, Verbal/Visual), and two levels of Test Time (Immediate, Delayed). A mixed factor analysis of variance (ANOVA) was used to analyze the quantitative data. The within-subjects factors also served as dependent

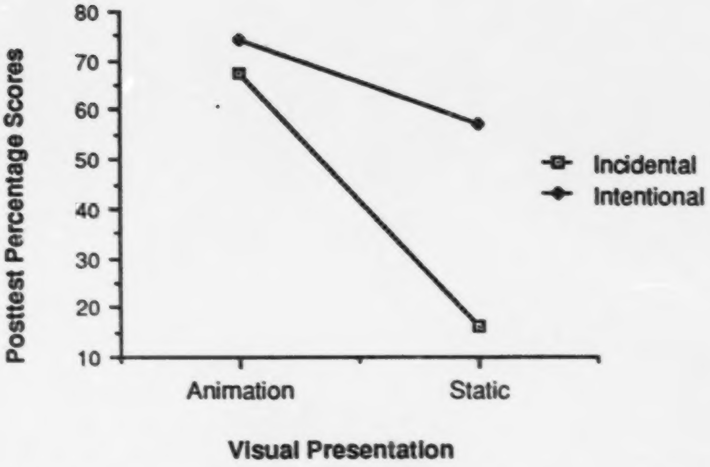
TABLE 1. *Mean Percent Scores and Standard Deviations for the Posttest*

			Immediate Posttest			
			Intentional		Incidental	
Visual Presentation	Practice Order		Verbal	Verbal/ Visual	Verbal	Verbal/ Visual
Animated Graphic	Questions/ Simulation	Mean	73.5	69.9	66.4	76.5
		SD	(30.7)	(27.3)	(29.4)	(28.3)
		n	17	17	17	17
	Simulation/ Questions	Mean	75.5	69.1	59.7	76.5
		SD	(24.4)	(26.2)	(32.0)	(36.8)
		n	17	17	17	17
Static Graphic	Questions/ Simulation	Mean	61.8	53.7	15.1	29.4
		SD	(21.9)	(27.2)	(13.8)	(28.6)
		n	17	17	17	17
	Simulation/ Questions	Mean	66.7	52.6	15.0	22.8
		SD	(35.1)	(31.6)	(25.0)	(31.5)
		n	19	19	19	19

			Delayed Posttest			
			Intentional		Incidental	
Visual Presentation	Practice Order		Verbal	Verbal/ Visual	Verbal	Verbal/ Visual
Animated Graphic	Questions/ Simulation	Mean	74.5	81.6	69.7	70.6
		SD	(28.3)	(18.8)	(27.6)	(37.0)
		n	17	17	17	17
	Simulation/ Questions	Mean	68.6	79.4	65.5	66.7
		SD	(25.6)	(18.2)	(27.7)	(37.3)
		n	17	17	17	17
Static Graphic	Questions/ Simulation	Mean	52.9	59.6	16.0	17.6
		SD	(21.4)	(28.5)	(23.6)	(33.6)
		n	17	17	17	17
	Simulation/ Questions	Mean	54.4	59.2	10.5	15.8
		SD	(37.6)	(32.8)	(24.2)	(28.0)
		n	19	19	19	19

Notes: SD-standard deviation; n-number of subjects

FIGURE 2. *Interaction between Visual Presentation and Learning Intent.*



measures. A Chi Square analysis was used to test students' first choice preferences of each post-lesson activity as a measure of continuing motivation of the practice questions and the simulation.

In addition, separate analyses were conducted on the questions measuring misconceptions of Newton's law of gravitation and the response latency data from the posttest.

Results and Discussion

Posttest

Percent means and standard deviations of student posttest scores are contained in Table 1. An a priori decision was made to ignore interactions involving three or more factors. A significant main effect was found for Visual Presentation, $F(1,66)=60.17$, $p=.001$, $MS_{error}=2649.37$. However, interpretation of this effect must be qualified because of its interaction with Learning Intent, $F(1,66)=18.73$, $p=.0001$, $MS_{error}=2249.61$. Figure 2 illustrates the nature of this interaction. Students in the Animated Graphics group performed similarly on both intentional (mean=74.2%) and incidental questions (mean=67.5%), whereas students in the Static Graphics group performed significantly better on intentional learning questions (mean=57.4%) than incidental questions (mean=16.3%). As expected, these latter students performed at about the guessing level on incidental questions. This result supports the first hypothesis of this study that students receiving animated demonstrations of incidental information would attend, understand, and retrieve this information when tested although no formal attempt was made to teach or explain the principle. The superiority of the Animated Graphics group over the Static Graphics group on intentional learning is consistent with previous research (Rieber, in press-b).

Among the within-subjects factors, significant main effects were found for Learning Intent, $F(1,66)=31.28$, $p=.0001$, $MS_{error}=2249.61$, and Visual Testing Format, $F(1,66)=5.39$, $p=.02$, $MS_{error}=306.59$. Not surprisingly, students scored higher on questions measuring Intentional Learning (mean=65.6%) than questions measuring Incidental Learning (mean=41.1%). Students scored higher on questions containing either a static or animated visual (mean=60.1%) than questions containing no visual (mean=51.4%). However, a significant interaction was found between these two factors, $F(1,66)=5.62$, $p=.02$, $MS_{error}=357.52$. Students tended to answer Incidental Learning questions which contained visuals more accurately than questions which contained no visuals. Student scores on questions measuring Intentional Learning did not vary significantly depending on the use of visuals in the questions. This implies that in this study, the use of visuals in the test construction did not measure differentiated amounts of intentional rule learning. However, test questions which included visuals did vary in their measurement of incidental rule learning.

Response Latency

A main effect was found for Test Time, $F(1,66)=46.13$, $p=.0001$, $MS_{error}=35.99$. Students took significantly less time to answer the posttest questions during the second administration of the posttest. Retrieval time would be expected to decrease during retesting, especially when the second administration occurred within 48 hours, as was the case in this study. However, an ordinal interaction was found between Test Time and Visual Presentation, $F(1,66)=5.48$, $p=.02$, $MS_{error}=35.99$. Students in the Statics Graphics group varied less in response time from the first and second administration of the posttest than students in the Animated Graphics group. This interaction is probably an artifact of the rate of guessing on incidental questions by the Static Graphics group.

A main effect was found for Learning Intent, $F(1,66)=80.89$, $p=.0001$, $MS_{error}=30.80$. Students took significantly less time to answer questions measuring Intentional Learning than questions measuring Incidental Learning. However, an ordinal interaction was also detected between Learning Intent and Visual Presentation, $F(1,66)=8.77$, $p=.004$, $MS_{error}=30.80$. Students in the Animated Graphics group took significantly longer to answer questions measuring Incidental Learning than students in the Static Graphics group. This was expected. Students in both Visual Presentation groups were required to overtly process incidental information for the first time during the posttest. Since students in the Static Graphics group had to revert to either guessing or personal experience, their latency rates for these questions would be expected to be lower than for students in the Animated Graphics group. These latter students were asked to answer questions pertaining to information which was only incidentally represented in the animated visuals. If students encoded the incidental information significant time would be necessary to retrieve this information and formulate a rule which could be used to answer the question. There was no difference in response time between Animated Graphics and Static Graphics groups for Intentional Learning.

A main effect was found for Visual Testing Format, $F(1,66)=126.97$, $p=.0001$, $MS_{error}=31.15$. Overall, students took much less time to respond to questions which contained either static or animated visuals than questions which contained no visual supplements. This too was expected. All of the information and testing was highly visual in nature. Questions which did not provide external visuals would require students to form their own internal or external (eg. doodles on paper) images in order to solve the problems. When visuals were provided with the questions, students could by-pass this time-consuming cognitive step, assuming that the visual was congruent with each student's mental schema. It is insightful to compare the latency and performance results for this factor. Even though the addition of external visuals to questions which measured intentional learning did not contribute to performance differences, the decrease in latency suggests that these visuals nonetheless aided the cognitive processing necessary for accurate responses.

Continuing Motivation

Respective first choice frequencies for each of the three post-lesson activities were as follows (the first number indicates the raw frequency and the second number indicates percentage of total first choices): Questions, 3, 4.3%; Simulation, 42, 60.0%; Puzzle, 25, 35.7%. For the purposes of the Chi Square analysis, answering more practice questions acted as a non-choice and was removed from the analysis. Overall, students first chose to participate in the structured simulation more often than either the puzzle activity or the practice questions, Chi Square=3.88, $p<.05$, $df=1$. This result supports the second hypothesis of the study which contended that the practice provided by the structured "starship" practice held intrinsically motivating appeal for the students. It is contended that this appeal would lead students to *choose* to stay on task longer in meaningful ways. This result further clarifies performance effects of this practice activity as reported by Rieber (in press-b).

Student Conceptions of Gravitation

A significant main effect was found for Visual Presentation, $F(1,66)=18.24$, $p=.0001$, $MS_{error}=1044.19$. Students in the Animated Graphics group (mean=5.9%) performed significantly worse on the two questions measuring a simple application of Newton's law of gravitation than students in the Static Graphics group. This suggests that students in the Animated Graphics group were more prone than other students to the misconception that Newton's second law predicts the free fall characteristics of objects of different masses on earth. This result provides an important counterbalance to the apparent ability of students to attend to animated visuals which incidentally demonstrates a scientific principle. While students may be appropriately attending to the details, they may be drawing a whole series of conclusions — some of which are appropriate, and some of which are not. This phenomena is consistent with previous research on other misconceptions in science where people formulate conceptions of physical phenomena based on daily observable events (see Eylon & Linn, 1988, for a review). Without direct guidance, such as that provided by instruction, students may formulate innumerous and potentially erroneous "theories" about the physical world.

General Discussion

There were two purposes to this study. First, the ability of students to first attend to incidental information contained in an animated visual, and then extract and induce science principles was investigated. The Animated Graphics group was given demonstrations of an extension of Newton's second law where the masses of two objects varied, but the forces acting on them remained constant. However, the fact that these demonstrations represented a distinct extension of this principle was never brought to their attention. In fact, the demonstrations were presented in the context of explaining other lesson content. It is believed that attention to intentional learning alone placed significant cognitive loads on students. Yet, they were able to gain understanding of the incidental information, without apparently sacrificing any intentional learning. The results reported here demonstrate the rather startling ability of fourth grade students to attend to, formulate, and apply even a sophisticated science principle introduced in an incidental fashion.

However, this result is tempered by the alarming number of students who continued to apply this incidental information to other, *inappropriate* contexts. Students in the Animated Graphics condition were much more likely to hold misconceptions about the effects of gravity on objects of different masses. This is not really surprising. The animated demonstrations of Newton's second law occurred in a simulated gravity-free/frictionless environment. The concept and effect of gravity was purposely removed from the discussion. Without additional guidance, it is logical and intuitive to apply Newton's second law to contexts where objects of different masses are freely falling on earth (such an intuitive assumption led Galileo to demonstrate otherwise at the leaning Tower of Pisa).

The second purpose of this study was to estimate the construct of intrinsic motivation as it related to several practice activities shown effective in CBI in previous research — questioning strategies and structured simulations. Understanding whether certain activities have intrinsic motivating appeal is important when designing CBI. If activities contain such appeal for students, they will be more likely to maintain interest and stay on-task for longer periods of time. This is because the focus of the reinforcement is internal — that is, students motivate themselves. This is contrast to traditional CBI, largely based on behavioral designs, where learning is believed to be the result of constant and appropriate *external* reinforcement. It can be argued that internal reinforcers account for most informal daily learning such as that experienced through hobbies and sports. Designers of CBI practice activities have many strategies from which to choose. It is argued here that while several activities may promote similar performance levels, activities which are intrinsically motivating carry other significant advantages such as personal satisfaction, challenge, and relevance and promotion of a positive perspective on lifelong learning (cf. Keller & Suzuki, 1988). Previous research has used student free choice patterns as a measure of continuing motivation (Kinzie & Sullivan, 1989). In this study, students overwhelmingly chose to return to the "starship" practice more often than questioning activities or even traditionally entertaining activities such as word-find puzzles to support the contention that the structured simulation carries intrinsically motivating appeal for students of this age. It is further contended that the activities, and not the computer, possesses these characteristics based on the fact that of the other two choices, the paper and pencil activity was overwhelmingly chosen over the remaining computer activity (questions).

This study has also provided preliminary findings concerning the role of visuals in computer-based testing. Testing learning outcomes which are highly visual in nature poses problems for researchers. A visual in a test question may actually act as an unintentional learning aid which could confound results. However, the validity of testing visual learning outcomes with solely verbal means can easily be questioned. Insights into this dilemma were hoped to be gained by controlling for visuals in the testing. In this study, the validity of questions measuring intentional learning was not related to the presence of visuals. Questions which did not contain visuals appeared to state the problem in terms which enabled students to form their own appropriate internal images. This was not true when measuring incidental learning. Students apparently had difficulty forming internal images on their own as they attempted to solve the problem. More work is needed to understand the role of visuals in testing (other examples include Hale, Oakey, Shaw, & Burns, 1985; and Taylor, Canelos, Belland, Mayton, & Dwyer, 1989).

Lastly, students in this study did not experience significant learning decay over the two day test-retest interval. Previous studies have indicated that picture effects are durable over long periods of time (Anglin, 1986; Peng & Levin, 1979). The results reported here support this contention.

In conclusion, this study has shown one example of the powerful ability of students to learn in incidental ways. Designers of CBI need to harness this ability by promoting it whenever possible while trying to avoid inappropriate student elaborations. One application of this research to the development of CBI may be to use incidental information as an orienting activity for subsequent intentional instruction. More research is needed to understand how to best incorporate incidental learning benefits into the design of CBI. Additionally, this study has provided strong evidence to suggest that certain computer practice activities contain intrinsically motivating appeal for elementary school students. Future research should be directed at replicating these results in other contexts and content areas.

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Title:

Factual and Inferential Learning Under Varying Levels of Information Processing

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FACTUAL AND INFERENTIAL LEARNING UNDER VARYING LEVELS OF INFORMATION PROCESSING

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ABSTRACT

The effects of overt, covert, and summary practice conditions on four levels of learning were examined. One hundred twenty two middle class sixth grade students were randomly assigned to practice condition. Passages regarding energy sources were read by the students and oral reviews were directed according to treatment. The summary group was given a review of relevant content, while covert and overt groups responded to adjunct questions. A thirty two item selected response test contained sixteen items from the practice booklet and sixteen new items not practiced by any treatment. Data were examined on four dependant measures (repeated fact, new fact, repeated inference, new inference). The results show that oral summaries of relevant information can be as effective as inserted questions on immediate and delayed test performance. This study suggests that practice condition and question type may differentially affect learning and retention.

Introduction

Cognitive theory generally holds that recall of textual information is strongly affected by the level of information processing (Craik & Lockhart 1972, Bretzing & Kulhavy 1979). Based on the theory that recall of textual information is a function of processing it was predicted that as reading comprehension tasks demanded a more complete interaction of the reader's existing schemata, and as the subjects were more actively involved in the learning process, higher levels of recall would be found (Glover 1982).

An underlying assumption in most practice condition research is that questions are beneficial to learning. Andre (1979) found that questions influenced the nature of the memory representations formed during instruction and that these representations controlled the way in which stored knowledge was used. Andre and Sola (1976), and Andre and Womack (1978) suggested that adjunct paraphrased questions guide semantic encoding of presented information and thereby lead to greater performance.

Many studies have demonstrated that treatments involving questions result in higher learned performance (Anderson & Biddle, 1975). After reviewing the research in this area, Dillon (1982) reported that adjunct questions had a consistent, but small, positive effect on the retention of information.

Two common practice conditions currently in the research are overt (verbal or written responses) and covert (internalized responses). Subjects in studies comparing the effects of these practice conditions have been typically presented written or verbal questions.

Many studies (Goldbeck & Campbell, 1962; Holland, 1960; Michael & Maccoby, 1961) have shown that both covert and overt responses facilitate student learning. Research has indicated that when verbalization follows an instructional segment, both question relevant and incidental subject content learning improve (Hershberger, 1964; Frase, 1968 & 1970).

Alternatives to the non-question control group have been used in many studies (Buggey, 1971; Ryan, 1973). Winne (1979) suggested the use of a summary group as a realistic classroom approach and non-question treatment. Research, however, has provided little information about the effects of such treatments.

Numerous studies have shown no significant differences between higher-cognitive and fact question teaching strategies (Andre, Mueller, Womack, Smid, & Turtle, 1980; Ryan, 1974; Bedwell, 1975; Savage, 1972). Others too have asserted that higher-level questions have little demonstrated relationship to student achievement (Gall 1970; Dunkin & Biddle, 1974). Frase (1968) reported that broader questions do not direct the learner's attention and therefore lead to poorer performance.

Some studies, however, have shown that application-type review questions facilitate a higher-order learning because they require the learner to apply acquired information to new situations. Yost, Avila, and Vexler (1977) reported that as the complexity of questions to which students responded increases, achievement increases. Their study found that higher-order questions generally facilitated posttest performance by directing attention to more information.

Differential effects for reading ability are well supported in research on adjunct questions. High readers generally score higher on content relevant tests than low readers. Question placement and question type greatly affect results (Richards & Di Vista, 1974). Many studies have found facilitative effects of questions across reading levels.

Experimental studies investigating immediate and delayed criterion test scores have revealed differential effects for practice condition and question type. Overt and covert responses have been equally beneficial when testing occurs immediately following instruction (Kanner & Sulzer, 1956). However, time delay in the administration of the criterion measure has revealed that overt responses are significantly more effective than covert (Goldbeck & Campbell,1962). Anderson (1970) states that due to depth of processing, higher-cognitive questions are retained longer than lower-cognitive questions.

The purpose of this study was to investigate the effect of overt, covert, and summary conditions on four levels of student learning. A 32 item posttest assessed the following: factual information presented and practiced in the instruction (repeated fact), factual information presented but not practiced in the instruction (new fact), information directly inferable and practiced (repeated inference), information directly inferable but not practiced in the instruction (new inference).

Method

Subjects

The original sample consisted of 148 sixth grade students from two elementary schools that served middle class suburban populations and were of equal size. Twenty six subjects were dropped from the study for absence from an experimental session or for failure to complete the attitude inventory. The final sample had a total of 122 subjects.

Materials

An instructional passage consisting of approximately 1100 words was adapted and modified from the "Power Switch" unit of the Energy Source Program (1982). Passages described eight potential energy sources of the future. The text was divided into nine sections, each containing two or three paragraphs. Paragraph length ranged from 50 to 65 words. The readability level of the material was 5.8 as determined by Brown's (1965) science text adaptation of the Dale-Chall readability formula.

Treatment booklets were developed for specific use in the three different practice conditions. Summary group booklets consisted of text only, while covert and overt group booklets contained adjunct questions. Inserted questions were located immediately after each passage. Booklets were 19 pages in length.

An introduction was included in all booklets. All groups were allowed practice on both factual and inferential questions.

Questions used in this study were submitted to experts who verified that inference questions did indeed require students to come to logical conclusions by using the information presented. Fact questions were found to require only simple verbatim recall from text.

Questions and text were submitted to a panel of five Educational Technology PhD candidates. They concurred that the inference questions could be answered by using only the information in the passage. They agreed that there was one best answer of the selected responses, and that distractors met instructional design criteria.

The questions for this study were first pilot tested with a group that did not read any of the passages. Questions used in this experiment were those which students received a chance percentage of approximately twenty-five percent correct. The items and text were then presented to fifty-one subjects who read the materials silently and answered all questions. From results of this pilot test, a pool of fact and inference questions, with overall equivalent difficulty and discrimination indices, was constructed.

The criterion test consisted of 32 items. Sixteen of these were new items and 16 were repeated from the text. Fact and inference items were represented equally and covered the same material but were not parallel questions.

Procedures

Subjects were ranked as high, medium, or low readers by their teachers. Standardized scores were not used for leveling subjects because this information was not made available at both schools. Groups were blocked for reading level and sex and subjects were randomly assigned to groups.

The three treatments were administered by PhD candidates trained in the experimental procedures. Each experimenter was randomly assigned to a group and presented the same practice condition to both schools.

During the experimental session all students were directed to their assigned classrooms. Experimenters handed out a pre-coded packet to each subject. All students received the same general instructions including a brief lesson and practice in answering fact and inference questions. Scripts for experimenters specified content, style of delivery, verbatim phrasings, and the sequence of questions to be asked.

Covert and overt groups were exposed to text, given a question to answer, and were called on by the experimenter to answer the question. Knowledge of correct response was summarized by the experimenter before proceeding to the next passage. The overt group was instructed to write responses on the line at the bottom of each page. The covert group was told to mentally select the best answer. Questions were purposely not labeled with a, b, c, or d. Therefore, when practicing responses or reporting to the group, students were required to repeat the answer itself and not simply the corresponding letter or number. The experimenter always responded to student answers according to the script. Both question groups received corrective feedback but no supplemental information.

The experimenter presented a scripted review to the summary group. This review covered the same facts and concepts as mentioned in questions given to both question groups. All information was presented in declarative form. Treatment time for both question groups was approximately one hour and 15 minutes. The summary group, which did not require teacher wait time for selection of answers, calling on students, or giving knowledge of results, took only fifty minutes. The immediate criterion test was administered when each group finished the materials. The delayed test was given exactly one week later.

Criterion Test

The 32 item selected response criterion test consisted of 16 repeated items, from question group booklets, and 16 new items. Half of the items were fact questions and half were inference questions. The immediate test and delayed test were identical.

Design and Data Analysis

A 3 (practice condition) X 3 (reading level) factorial design was used. Data were examined with four dependent measures (repeated fact, new fact, repeated inference, new inference). Each multivariate analysis of variance was followed by a univariate analysis. Immediate and delayed tests were reviewed separately.

Results

Mean scores by practice condition, question type, and reading level on the 32 item immediate test are presented in Table 1. Table 2 displays the mean scores for the delayed test. A summary table for univariate and multivariate analysis of variance is shown on Table 3.

Results are discussed below by immediate test, delayed test, and gain scores.

Table 1

Mean Scores on Immediate Test

Reading Level and Condition		Fact Repeated Items	Fact New Items	Inference Repeated Items	Inference New Items	Grand Total
High						
Overt	x	7.18	4.71	6.59	4.35	22.82
	SD	.73	1.40	1.28	1.50	3.63
Covert	x	7.08	4.92	5.83	4.33	22.17
	SD	1.16	1.56	1.64	1.23	4.30
Summary	x	5.92	6.15	6.38	5.77	24.23
	SD	1.26	.90	1.45	1.42	3.75
Medium						
Overt	x	5.82	4.88	5.53	3.71	19.94
	SD	1.85	1.76	2.18	1.36	5.10
Covert	x	5.73	4.33	5.00	4.27	19.33
	SD	1.91	1.95	2.27	1.91	6.06
Summary	x	5.06	5.94	4.94	4.76	20.71
	SD	1.52	1.03	2.30	1.79	4.70
Low						
Overt	x	5.27	3.36	4.09	3.36	16.09
	SD	1.56	2.38	1.38	1.43	5.36
Covert	x	4.40	3.50	3.30	2.70	13.90
	SD	2.55	1.65	2.06	1.42	5.49
Summary	x	3.10	4.30	3.70	3.10	14.20
	SD	1.97	1.25	1.64	2.47	6.21
Total	x	5.64	4.78	5.19	4.13	19.74
	SD	1.94	1.76	2.09	1.79	5.18

Practice Condition		Reading Level		Question Type	
Overt	20.09	High	23.07	Fact	10.42
Covert	18.79	Medium	20.02	Inference	9.32
Summary	20.23	Low	14.77		

Immediate Test

Practice condition

As shown in Table 1, the mean scores for the immediate criterion test were 20.09 for overt, 18.79 for covert, and 20.23 for summary groups. The multivariate analysis of variance (Table 3) revealed a significant effect for practice condition ($\underline{F}$ (8,222)= 6.02, $\underline{p}<.0001$).

Scheffe's multiple comparison test found significant differences on repeated fact and new fact items, but not on repeated inference or new inference items. On repeated fact items, the mean scores of 6.20 for the overt treatment and 5.81 for the covert treatment were significantly higher than the mean of 4.85 for the summary group, $\underline{F}$ (1,113)= 3.07, $\underline{p}<.05$. On new fact questions the situation was reversed. The mean of 5.60 for the summary group was significantly higher than the means of 4.44 for the overt treatment and 4.29 for the covert treatment, $\underline{F}$ (1,113)= 3.07, $\underline{p}<.05$.

Reading Level

Significant effects for reading level, $\underline{F}$ (8,222)= 5.88, $\underline{p}<.001$) on the immediate test were supported by univariate F-tests with significance on all four dependent measures, $\underline{F}$ (2,113), $\underline{p}<.0001$. High readers (23.07) and middle-level readers (20.02) scored significantly higher than low readers (14.77) on new fact, repeated fact, new inference. and repeated inference items, $\underline{F}$ (1,113)= 3.07, $\underline{p}<.05$. High readers scored significantly higher than middle-level readers on only the repeated fact and repeated inference questions, $\underline{F}$ (1,113)= 3.07, $\underline{p}<.05$. This held true across practice conditions.

Question Type

The difference on overall performance on fact questions (10.42) and on inference questions (9.32) was statistically significant, $\underline{F}$ (1,120)= 119.13, $\underline{p}<.001$. The correlation of F1 (immediate fact questions) with I1 (immediate inference questions) was .85.

Interactions

Multivariate analysis of variance revealed no significant interaction effects for the immediate test.

Table 2

Mean Scores on Delayed Test

		Fact		Inference		
Reading Level and Condition		Repeated Items	New Items	Repeated Items	New Items	Grand Total
High						
Overt	x	6.59	5.00	6.76	5.35	23.71
	SD	.94	1.70	1.40	1.27	3.80
Covert	x	6.08	5.17	5.17	3.92	20.33
	SD	1.91	1.80	1.99	1.38	6.18
Summary	x	5.15	5.31	5.62	5.92	22.00
	SD	1.91	1.70	2.02	1.32	5.64
Medium						
Overt	x	5.41	4.00	4.76	3.29	17.47
	SD	2.00	2.03	2.28	1.36	6.24
Covert	x	5.00	3.53	4.47	3.60	16.60
	SD	1.96	2.10	1.88	2.03	5.93
Summary	x	4.47	5.34	4.71	5.41	19.82
	SD	1.70	1.48	1.86	1.58	4.42
Low						
Overt	x	3.91	3.45	4.09	3.00	14.05
	SD	2.77	1.29	1.30	1.90	4.27
Covert	x	4.50	3.00	3.80	2.70	14.00
	SD	2.55	2.00	1.93	1.06	5.48
Summary	x	2.30	2.60	2.40	2.80	10.10
	SD	1.25	.84	.84	2.10	3.87
Total	x	4.97	4.26	4.80	4.14	18.16
	SD	2.20	1.92	2.07	1.92	6.35

Practice Condition		Reading Level		Question Type	
Overt	18.99	High	22.21	Fact	9.23
Covert	17.10	Medium	18.02	Inference	8.94
Summary	18.10	Low	12.90		

Table 3

Source Table for Univariate and Multivariate ANOVA for Fact and Inference Questions

Source of Variance	Question Type	df	MS	Univariate F	p<	*Multivariate Approximate		
						df	F	p<
Immediate Test								
Practice Condition	FR1	2	20.92	7.82	.001	8	6.02	.001
	FN1	2	17.92	7.15	.001			
	IR1	2	4.78	1.37	.259			
	IN1	2	7.37	2.76	.068			
Reading Level	FR1	2	54.07	20.22	.001	8	5.88	.001
	FN1	2	23.86	9.52	.001			
	IR1	2	58.36	16.69	.001			
	IN1	2	27.95	10.46	.001			
Condition by Level	FR1	4	1.73	.65	.629	16	.70	.792
	FN1	4	.92	.37	.830			
	IR1	4	.38	.11	.980			
	IN1	4	3.01	1.12	.348			
Within Subject Error	FR1	113	2.67					
	FN1	113	2.51					
	IR1	113	3.50					
	IN1	113	2.67					
Delayed Test								
Practice Condition	FR2	2	21.18	5.51	.005	8	4.78	.001
	FN2	2	2.14	.72	.491			
	IR2	2	10.40	3.19	.045			
	IN2	2	16.32	6.57	.002			
Reading Level	FR2	2	49.67	12.92	.001	8	5.62	.001
	FN2	2	40.41	13.50	.001			
	IR2	2	52.01	15.93	.001			
	IN2	2	43.91	17.68	.001			
Condition by Level	FR2	4	2.45	.64	.637	16	1.24	.231
	FN2	4	5.31	1.77	.139			
	IR2	4	4.79	1.47	.217			
	IN2	4	7.23	2.91	.025			
Within Subject Error	FR2	113	3.85					
	FN2	113	2.99					
	IR2	113	3.27					
	IN2	113	2.48					

*The Multivariate F value reported is Pillais' approximate F.

Delayed Testing

Practice Condition

As shown in Table 2 the mean scores for the delayed test were 18.99 for overt, 17.10 for covert, and 18.10 for summary groups. A significant effect was obtained for practice condition, F (8,222)= 4.78, p<.001. The overt group outscored the summary group which in turn scored higher than the covert group. This delayed finding differed from the immediate test results which favored the summary group over both the overt and covert practice groups.

The analysis of performance by type of question yielded differences for repeated fact and new inference questions. On repeated fact items, the mean scores of 5.49 for the overt treatment and 5.22 for the covert treatment were significantly higher than the mean of 4.15 for the summary group, F (1,113)= 3.07, p<.05. Both practice groups also had significantly higher scores than the summary group for repeated fact items on the immediate test.

On new inference items, the mean score of 4.93 for the summary treatment was significantly higher than the mean scores of 4.00 for the overt treatment and 3.46 for the covert treatment, F (1,113)= 3.07, p<.05. Scores did not differ significantly between groups on new inference items on the immediate test. There were no significant differences on the delayed test on either new fact items or repeated inference items. On the immediate test, the summary group had scored higher than the other two groups on new fact items, but scores did not significantly differ for groups on repeated inference items.

Reading Level

Reading level was highly significant for the delayed criterion test, F (8,222)= 5.62, p<.0001 with all four dependent measures significant at the .001 level. Again, high readers (22.21) and middle-level readers (18.02) scored significantly higher than low readers (12.90) on all four question types, F (1,113)= 3.07, p<.05. High readers scored significantly higher than middle-level readers on repeated fact, repeated inference, and new inference questions, F (1,113)= 3.07, p<.05. This finding differs from the immediate test where no significance between groups occurred on new inference items.

Question Type

The difference on overall performance on fact questions (9.23) and inference questions (8.94) was again statistically significant, F (1,120)= 99.62, p<.001. The correlation of student scores on delayed fact questions with delayed inference questions was .67.

Interactions

A significant interaction for the delayed test was found on new inference items, F (4,113)= 2.91, $p<.02$.
Figure 1 shows that this interaction was primarily due to the poor achievement of high readers in the covert group.

Gain Scores

Differences between the immediate and delayed test scores were significant, F (1,120)= 139.99, $p<.001$. Univariate analysis were run using gain scores for all dependent variables. Scheffe's multiple comparison test found no significance for reading level.

Significant effects were found for practice condition on new inference and repeated inference items. On new inference items, there was a significant difference between the summary condition and the overt condition, F (1,113)= 3.07, $p<.05$. These results are difficult to interpret due to the interaction effects found for new inference questions. It does appear, however, that this significant gain score effect was primarily due to the difference in scores of the middle-level readers in these treatments.

Significant differences between practice conditions were found for the overt and summary conditions, and the covert and summary conditions on repeated inference items, F (4,133)= 3.07, $p<.05$. This effect appears to be due to the difference in scores of the high readers in each practice condition.

Discussion

In this study the summary treatment subjects displayed higher levels of recall on all new fact and new inference test items than either question treatment groups. It stands to reason that what the subjects in the summary condition remembered was a function of the cues provided for them by the experimenter during encoding. Tulving and Thompson (1973) found that the effectiveness of any retrieval cue was dependent on its being encoded with the material to be remembered. Summary subjects were given paraphrased concepts and cues which could be encoded simultaneously.

The interspersed questions required students in the covert and overt groups to utilize the information they had read. This

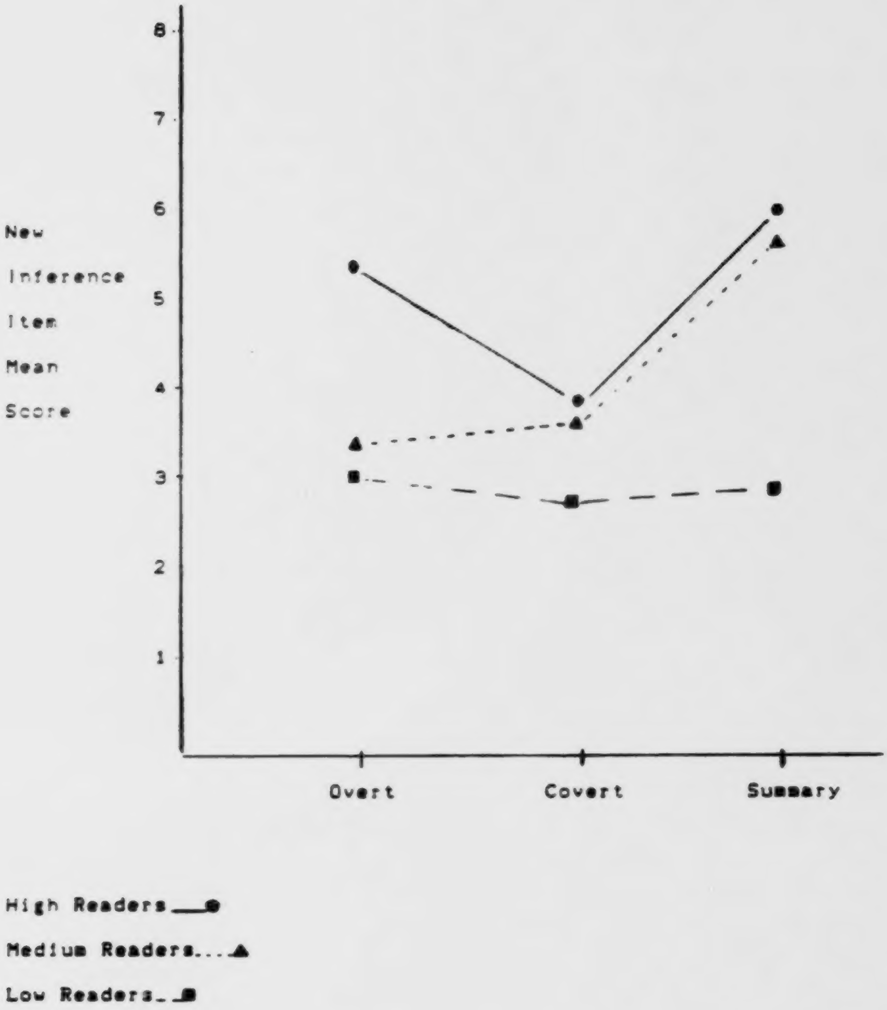

Figure 1. Practice condition by reading level interaction: Delayed Test

introduced a practice factor. Unlike many studies in the literature (Bourne & Haygood, 1959; Callantine & Warren, 1955), this study found practice in question form to have only a slight facilitative effect on achievement. Covert and overt practice groups were not found to perform significantly better than the summary group that received no questions or practice on specific test items. A post hoc error analysis found that overt treatment subjects who had selected the wrong answer for any inserted question in practice were more apt to select that same wrong answer on the posttest. The correct response was not selected on the posttest even though the students received immediate verbal feedback in practice indicating the correct response.

The overt subjects performed significantly higher than the covert subjects across all reading levels. Lack of compliance to practice condition by covert subjects may have accounted in part for these results. It is likely that these results vary according to the motivation of the students in the covert group.

The results of this study suggest that practice condition and question type may differentially affect learning and retention. Overt and covert practice facilitated recall of repeated factual items, whereas, summary subjects scored significantly higher on new fact and new inference items. As evidenced by total mean scores, allowing students to practice factual test items in treatment increased test scores on those exact items. However, this effect was not found for inference items. Recall of repeated inference items and other relevant content was not facilitated through the use of questions.

The Keenan et al (1978) study found that questions elicit pupil attention and direct it to specific content. In the research done by Allen (1970), subjects did better on questions relating to information they were asked about in adjunct questions. In this study, the practice of specific fact questions may have actually directed the students' attention away from other facts. Similarly, practice in answering inference questions did not better prepare those subjects in the covert and overt group to answer new inference questions, but again seemed to direct student attention from relevant content.

The summary condition scored significantly higher than the covert and overt groups on new fact items. These items were not practiced in any form by any treatment. Subjects in the covert and overt question groups may have been distracted from relevant content by reading only for answers to questions. This type of depressive effect of questions on recall was recognized in the Rickards and Denner (1979) study. In this study this effect was also found on inference questions. Repeated inference scores were similar for all treatments, however, the summary group scored significantly higher than both question groups on new inference items.

The importance of appropriate placement of questions is well established. Richards and Di Vista (1974) found that when questions were inserted after every two paragraphs, meaningful learning questions led to superior performance. This effect disappeared when questions were asked after four paragraphs. Results from this study show that questions asked after every paragraph did not increase student achievement and may have interferred with processing and encoding of new information.

The literature is far from conclusive about the effects of higher level questions. The nature of inference questions requires that a reader state a relationship between elements of a passage. This involves more complex cognitive processing and has proven a more difficult task, especially for low readers. In this study, fact scores were significantly higher than inference scores. However, inference questions had a slight facilitative effect on retention. This was exhibited by the difference in immediate and delayed test scores for fact and inference questions. Inference question scores remained similar on the immediate and delayed tests, whereas, scores for fact questions fell sharply on the delayed test. This is consistent with the Craik and Tulving (1975) study where conceptually based items, requiring greater depth of processing, were better retained than the items requiring recall operations.

The summary group was a highly effective treatment. On new fact items, new inference items, and repeated inference items the summary group scored consistently high. This held true across all reading levels for both immediate and delayed tests. The summary treatment highlighted facts and concepts in narrative form and reinforced only relevant content. The questioning treatments, whether overtly or covertly practiced, appear to have allowed encoding of distractors and incorrect responses. Therefore the results of this study would warn that questioning strategies are beneficial only to the extent that the correctness of the response can be controlled in a practice situation.

Treatment times varied dramatically among the practice conditions. The two question treatments were one hour and fifteen minutes long. The summary treatment took only fifty minutes. With this in mind, and comparing the overall immediate and delayed test scores, the summary practice condition was the most effective and efficient treatment for all level readers.

Reading level was significant across treatments. High readers scored equally well on fact and inference items. Medium and low readers generally scored higher on fact questions as compared to inference questions. These results are consistent with previous literature in this area and suggest that reading ability directly affects student competency in answering inference questions.

Overall gain scores for the three groups show that overt subjects' scores tended to remain more constant than those of the covert and summary subjects. Although immediate test scores for the overt group were not as high as the summary group, the overt participation appears to have facilitated long term retention.

On the delayed test a practice by reading level interaction was found for new inference items. As stated above, generally scores were lower on the delayed test. The covert group scored consistently lower on the delayed test across reading levels. However, the high readers in the overt treatment and the medium readers and high readers in the summary treatment scored significantly higher on the delayed test on new inference items. The interaction appears to be due to the overt and summary conditions that were especially effective, over time, for higher readers. Studies using delayed testing (Goldbeck & Campbell, 1962; Krumboltz & Weisman, 1962) have shown overt treatments to be more effective than covert treatments. However, little previously has been reported about summary treatments.

From the immediate measure to the delayed measure repeated items fell more than new items. It appears that practice of items in question form leads to short term retention of answers. Immediate results of repeated items were higher due to a practice factor. However, delayed test results show that practice of specific answers is far less effective over time than general knowledge of the content itself.

The results of this study suggest differential relationships between two question treatments and the summary treatment with respect to performance on repeated items and performance on new items. This is of importance for instructional planning and program development. The present study indicates that further research in this area is needed to better determine the nature of these relationships and implications in regard to affectiveness of the different practice conditions with respect to factual and inferential learning. Oral summaries should continue to be considered as viable alternatives to questioning strategies and deserve further investigation.

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Title:

Uses and Effects of Learner Control of Context and Instructional Support in Computer-Based Instruction

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Uses and Effects of Learner Control of Context and Instructional Support in Computer-Based Instruction

Cognitive views regarding the effective teaching of mathematical and scientific knowledge are increasingly emphasizing the importance of making connections between the learner's existing knowledge structure and new information to be learned (Mayer, 1984; Peterson, 1988). This basic principle has been applied in classroom teaching through such strategies as integrating new material with class field trips (Wright & Stevens, 1983), with stories written by the students themselves (Bush & Fiala, 1986; Ferguson & Fairburn, 1985; Hosmer, 1986; Leonardi & McDonald, 1987) or with interesting materials published in books (Jones, 1983) and newspapers (Daruwalla, 1983). It has also been demonstrated numerous times in basic research studies. Ross and his associates (Ross, 1983; Ross, McCormick, & Krisak, 1983), for example, adapted the thematic context of explanations and examples on a statistics lesson to college students' academic majors in education or medical fields. Results consistently showed higher performance, particularly on transfer problems, for the adaptive condition relative to a control group.

Although learner backgrounds in the latter studies (e.g., Ross, 1983) were well-defined (education vs. medical), they are often unknown and much more diverse in real-life teaching situations. Accordingly, material that is potentially meaningful and motivating to one student may fail to be so for another given differences in backgrounds and current interests. Unfortunately, the individual teacher will normally lack sufficient time and resources to arrange appropriate individualized options. Recognizing these limitations, especially for elementary school students, Anand and Ross (1987) used microcomputers to personalize mathematical story problems for children by embedding information about each child (e.g., hobbies, friends' names) in the problem context. Children who received the personalized examples performed better and reacted to the lesson more positively than did those who received conventional problems (also see Ross & Anand, 1987). Despite these benefits, practical limitations of this strategy are the time needed to collect and input personalized data, and the questionable appeal of the personalized contexts over time, (i.e., after novelty effects have diminished).

An important goal for instructional technology research is to translate basic research findings into applied strategies that can be implemented in classroom and training settings (Clark, 1989; Winn, 1989). Accordingly, one purpose of the present research was to develop a more practical model for adapting context to learner interests. Our specific approach used CBI to make alternative contexts for statistics problems (i.e., sports, business, education, no-context) available for selection by individual learners. In this manner, adaptations were individualized, immediate, and applicable in feasibility and potential appeal to students at a wide range of grade levels. A second research interest was evaluating the context adaptation strategy when used both independently of and in combination with learner control (LC) of the number of practice examples. Although LC is a significantly more cost-effective individualization strategy than developing "program-control" models to make selections for students (e.g., Hansen, Ross, & Rakow, 1977; Tennyson & Rothen, 1977), the question has been raised whether the typical student possesses sufficient knowledge and interest to make effective decisions (see reviews by Hannafin, 1984; Ross & Morrison, 1989; Steinberg, 1977). Specifically, when a learning task is relatively difficult or ability is low, learners may be inclined to select less instructional support so they may exit earlier from the task (Carrier, Davidson, & Williams, 1985; Ross & Rakow, 1982; Tennyson, 1980). The present rationale was that if the examples were made more meaningful by conveying familiar contexts, motivation to use them as a learning resource should increase.

To investigate these questions, the present design involved the manipulation of standard (prescribed) contexts versus LC-context in combination with standard instructional support versus LC-instructional support. One hypothesis was that the LC-context would result in superior learning and more positive task attitudes relative to standard contexts as a result of allowing learners to choose more meaningful topics that make relevant problem information easier to translate. Second, it was predicted that when learners could choose preferred contexts, they would be more receptive to the material and thus increase their selection of instructional support. In addition to testing these assumptions, a primary focus of the study was analyzing the nature of LC decisions in relation to the types of instructional options made available and learner characteristics.

Method

Subjects and Design

Subjects consisted of 227 undergraduate students enrolled in required education courses at Memphis State University. They received credit toward their course grade for participating. Subjects were preassigned at random to 15 treatments formed by crossing 5 types of context (sports, education, business, no-context, and LC) with 3 conditions of instructional support (minimum, maximum, and LC). Absences by several subjects who were originally assigned to treatments resulted in slightly uneven group sizes, ranging from 13 to 17. Major dependent variables consisted of achievement on three types of posttest items (definition, calculation, and transfer) and attitudes toward the lesson. Achievement scores were analyzed via a 5(context) x 3(support) MANOVA. For attitude data, separate 5 x 3 ANOVAs were performed on individual items scores and on the composite score.

Instructional Material and Treatments

All subjects completed the identical introductory statistics unit presented by computer. The unit, which was adapted from materials developed by Morrison, Ross, and O'Dell (1988), teaches principles of central tendency in eight separate lessons: (1) computing the mean from simple data, (2) computing the mean from frequency distributions, (3) computing the median with an odd number of scores, (4) computing the median with an even number of scores, (5) determining the mode, (6) selecting the median over the mean (Case I: open-ended), (7) selecting the median over the mean (Case II: extreme scores), and (8) relative positions of the mean and the median in skewed and symmetrical distributions. Each unit contained an instructional section that presented an explanation for the particular topic, followed by four practice examples. The explanatory sections were identical for all treatments, but the practice examples were intentionally constructed to convey one of four context variations, as described below.

Education contexts described situations involving teachers and students in school settings, such as scores on a national spelling test, number of absences from school, years of experience of "Master Teachers," and IQ scores. Sports contexts involved situations such as free-throw accuracy in basketball, strike-outs in a softball game, rushing yards in football, times in a 440-yard dash, and so on. Business contexts mainly involved sales and marketing of products, such as the number of magazines sold per week, number of dresses sold in a four-day period, repair rates for appliances, prices of coffee beans, etc. No-context problems presented only the numerical values needed to solve the problem, without a supporting verbal context. Parallel problems comprising the four context sets were identical in structure, numerical values, and in the resultant numerical solution. Subjects assigned to the four standard context treatments received the same context on all examples. At the beginning of each lesson, LC-context subjects selected the one they preferred from the four options. The selected context was then presented on all lesson examples.

Instructional support variations involved the presentation of four examples on each lesson in the "maximum" condition and one example on each lesson in the "minimum" condition. In the LC condition, subjects were presented with the first example and, after viewing it, were asked whether they wanted to receive another. This LC option was then repeated after the second and third examples, but not the fourth, thus allowing a range of one to four examples on each of the eight lessons. The various example prototypes were presented in the same sequence in all treatment variations.

Instructions encouraged students to try to work the problems on their own. When ready, they could press the space bar to see the solution steps and final answer. They could then back page to study the problem again or progress to the next problem or segment. To increase experimental control over learning activities, the lessons and associated problems were administered sequentially with no opportunity to skip any content or to review old examples.

Instrumentation

Instruments used in the experiment are described below in the order in which they were administered. The first four measures consisting of the pretask attitude survey, reading test, computer attitude test, and unit pretest, were administered prior to the experimental session.

Nelson-Denney Reading Test. Subjects took the "comprehension and rate" section of Form D of the Nelson-Denny Reading Test (Brown, 1976). Comprehension was measured by having them read eight paragraphs and answer multiple-choice questions on each. Reading rate was measured by asking them to record the number of the line they had reached following the initial 60 seconds of reading.

Unit pretest. The unit pretest (paper-and-pencil mode) contained 10 items on material to be covered in the instructional unit. Five of the items assessed definitional knowledge, three assessed problem solving (calculations), and two assessed applications. The problems were parallel forms of those used on the posttest, with approximately one-fourth to one-third of each type represented. The KR-20 internal-consistency reliability of the pretest was determined to be .76.

An independent pretest item asked subjects to assume that they were about to take a mathematics lesson in which they could study examples relating to different themes (i.e., education, sports, business, no-context). They were then asked to rank the four contexts in order of preference ("1"= most desirable).

Unit posttest. A printed unit posttest, adapted from Morrison et al. (1988), contained 34 items (total points = 43) organized into three subtests. The knowledge subtest (17 items) assesses recognition or recall of definitional information exactly as it appeared in the text. The calculation subtest contained six problems requiring computation of central tendency measures from new data not used in lesson examples. The transfer subtest consisted of seven problems that involved interpreting and explaining the rationale for how central tendency would vary with changes in distributions or individual scores. Items of this type were not included in the lesson, nor were the underlying principles explicitly stated. On all transfer items, there was essentially one correct explanation for the effect in question. Scoring, which was done by two of the authors, was therefore straightforward in nearly all cases. Where an answer was ambiguous or partially correct, the two scorers examined it jointly and reached a mutual scoring decision.

Scoring rules on objective items and calculation problems awarded one point for a correct answer. On interpretative items, one point was awarded for a correct answer and an additional point for a correct explanation. The total test KR-20 reliability was .90. Transfer subtest reliability was .84.

Task attitude survey. A survey consisting of six Likert-type items was used to assess subjects' reactions to the task and materials. Internal-consistency reliability was .54. LC-context subjects reacted to two additional items, one asking whether examples with familiar themes were easier to learn, and the other whether receiving a mixture of themes is preferable to experiencing only one theme. They were also asked open-ended questions, regarding the desirability of being able to select contexts and to learn from a computer.

Results

Achievement

Posttest achievement was analyzed via a 5(context) x 3(instructional support) MANOVA with the knowledge, calculation, and conceptual subtests as dependent variables. None of the sources of variance was significant. Examination of means, as shown in Table 1, showed little difference between treatments, with 10 out of the 15 treatment means being within 1.5 points of the overall sample mean of 27.45 (64% correct).

Insert Table 1 about here

Attitudes and completion time. Analyses of individual attitude items on the follow-up survey and total score showed only one effect. As might be expected, subjects who received minimum support found the lesson faster moving ($p < .04$) than those who received maximum support. Overall, most items evoked fairly mixed reactions with the median response falling between "undecided" and "agree." The lowest mean ratings on the six core items (items received by all subjects) were for "the lesson moved quickly" and "I prefer this method of learning over lecture." The highest mean ratings were for "sufficiency of instruction" and the "readability of the layout." Interestingly, the most favorable reactions on the entire survey occurred on the LC item concerning the desirability of learning from familiar themes (M = 4.11), with 89% of the sample indicating either strong agreement (25%) or agreement (64%). Only 41% agreed or strongly agreed, however, that they would prefer a mixture of themes rather than the same theme throughout, but this response did not correlate with actual tendencies to change themes during instruction. Finally, the two-way ANOVA on completion time showed the instructional support main effect to be the only significant result ($p < .05$). As would be expected, the ordering of treatments from most to least time was maximum ($M = 30.0$ min.), learner-control ($M = 26.7$), and minimum ($M = 25.4$).

Open-Ended Attitude Responses

Qualitative analyses of open-ended responses regarding the desirability of selecting problem themes showed 92% to be positive, 5% neutral, and only 3% negative. Follow-up analyses of the positive responses indicated that the most frequently given rationale (38%) specifically mentioned the advantages of context selection for relating the material to existing knowledge or experiences. Examples were: "Wonderful, I was able to relate it (the materials) to something I understood," and "It was good to see that central tendency can be applied to everyday living situations." Other, lesser used response categories consisted of "General" (37%; "I liked it"), "Interest" (16%; "The context made the problems more interesting"), "Familiarity" (11%; "I am sports minded, so I felt more comfortable with sports"), and "Variety" (5%; "I liked choosing the themes because I was able to add variety").

In response to the question about the desirability of learning math by computer, the responses were mixed, with 58% classified as positive, 14% as neutral, and 28% as negative. The most frequently mentioned positive aspects were the self-pacing and feedback components. Most frequently mentioned as a negative factor was the lack of interaction with a human teacher.

Learner Control Outcomes

Additional analyses examined LC-context and LC-instructional support outcomes and their relationship with individual difference variables consisting of gender, pretest score, task attitude score, reading ability, and total posttest score.

Context rankings and preferences. On the pretest, subjects were asked to rank the four contexts in order of preference. As shown in Table 2, the ordering of mean rankings (lower mean = higher preference) and of frequencies with which the contexts were ranked first was education highest, followed by sports, business, and no-context. Statistical comparison of number one rankings across contexts indicated a highly significant difference, ($p < .001$). Gender differences were also highly significant, ($p < .001$): males were more likely to rank sports highest (66%) than were females (14%), while the converse occurred for education (17% vs. 52%).

Insert Table 2 about here

Also, as shown in Table 2, the relative frequencies with which contexts were actually selected across the eight lessons were ordered similarly to initial rankings with the most popular choice, education, being selected on almost half of the eight trials ($M = 3.66$), followed by sports ($M = 1.88$), no-context ($M = 1.61$), and business ($M = .91$). Comparison of the four context selection scores, using the nonparametric Freidman ANOVA By Rank test (Hays, 1981), were significant, (3) = 19.86, $p < .001$, thus confirming the observed preference differential. Analyses of gender differences were significant on three of the contexts: males were more likely than females to select sports ($p < .05$), but less likely to select no-context ($p < .01$) and education ($p < .001$). Correlations between pretest scores and selection totals further revealed that higher prior achievement was associated with a greater tendency to select the no-context option, r (44) = .32, $p < .05$, and a lesser tendency to select the education context, r (44) = -.47, $p < .001$.

Context selection patterns. Variations in context preferences during learning were examined by tabulating the number of times selections were changed across adjacent lessons (maximum score = 7). Results showed that 39% of the subjects selected the same context on all lessons, 25% made 1 or 2 changes, and 36% made 3 or more changes. Fourteen percent of the total group sampled all four options, and 25% examined at least three out of four. Change scores were not found to be correlated with any of the individual difference variables.

Other results revealed that differences in the relative frequencies with which the four contexts were selected early (Lesson 1) compared to late (Lesson 8) in the task were not significant. Students who selected the no-context option had significantly higher pretest scores than those who selected the education context on both Lesson 1 [M = 64% correct vs. M = 21% correct, t(25) = 3.72, $p < .001$] and Lesson 8 [M = 45% vs. M = 19%, t(27) = 2.54, $p < .05$].

Instructional support selections. The total quantity of examples selected across the 8 lessons ranged from 8 to 32, with a standard deviation of 6.5. The distribution was positively skewed, with a mean of 15.5 (1.9 per lesson), median of 13.5, and mode of 11.0. As expected, total quantity selected was negatively correlated with pretest scores, r (75) = -.26, $p < .05$.

Examination of the total quantity of examples selected by each context group showed that the means were ordered in the predicted direction with the no-context mean lowest (M = 12.0) and the LC mean (M = 18.5) highest. Fairly comparable means were obtained for the three thematic contexts, education (M = 16.0), sports (M = 16.7), and business (M = 14.6). For purposes of analysis, the data for the three thematic context groups were pooled, resulting in a three treatment group ANOVA design: standard thematic context, no-context, and LC. The treatment effect was significant, $F(2,72) = 4.21$, $p < .02$. Follow-up comparison of means, using the Tukey-HSD procedure, showed that LC subjects selected significantly more ($p < .05$) examples than did no-context subjects, but not more than subjects reviewing thematic contexts.

Support selection patterns. Tabulations of the number of times subjects varied their selections of examples across adjacent lessons (maximum score = 7.0) revealed an overall mean of 2.63 (a 38% rate). Overall, 91% of the sample varied their support selections at least one time. Three individual difference variables were related to these tendencies. Selection changes were more frequent for females (M = 2.87) than for males (M = 1.33), $t(73) = 3.08$, $p < .001$; for slower readers than for faster readers, r (75) = -.24, $p < .05$; and for higher posttest performers, r (75) = .24, $p < .02$.

Correlations Between Learner Variables and Experimental Outcomes

Correlations between learner characteristics and task outcomes generally revealed the expected tendencies for learners with higher prior achievement (pretest scores) and reading ability to complete the task faster, score higher on the posttest, and view the task more favorably. To examine these relations from a multivariate perspective, separate multiple regression analyses, using step-wise entry of variables, were conducted on each of the three criterion variables: posttest, attitudes, and time. Each criterion variable was entered as a predictor for the other two, along with pretest score, total number of examples received, reading rate, and reading comprehension. Results for the posttest showed significant predictors, in order of entry, to be pretest, mathematics attitudes, and reading comprehension ($R^2 = .35$, $p < .001$); for task attitudes, predictors were pretest and reading rate ($R^2 = .08$, $p < .001$); for completion time, they were number of examples, pretest, and reading comprehension ($R^2 = .15$, $p < .001$).

Discussion

The achievement results of this study failed to support the hypothesized benefits for learning of allowing learners to select preferred contexts for practice examples. However, findings regarding selections of instructional support and context in LC conditions provided some interesting insights into how learner control is used by different types of students as well as suggestions for increasing its effectiveness as a CBI strategy. Also, compared to earlier applications (Ross, 1983; Anand & Ross, 1987), a practical model for incorporating contextual adaptation in CBI was developed and demonstrated.

With regard to achievement, the instructional material appears to have been somewhat difficult for students given the scope and conditions of the learning task. In the regular self-paced statistics course from which the present lesson was adapted, students generally take two or three days (presumably involving at least several hours of self-study) to complete essentially the same unit of material and average approximately 89% on a comparable test compared to the present average of 64%. Accordingly, as suggested by the multiple regression data, achievement was strongly related to subjects' abilities and prior learning (pretest, math attitudes, reading ability), but generally independent of task variables. Even the amount of instructional support received, a highly influential variable in most learning situations (Carrier & Williams, 1988; Ross & Rakow, 1982; Tennyson & Rothen, 1977), had no impact on performance. An additional factor that might have attenuated contextual effects compared to previous studies (Ross, 1983; Ross, et al., 1986) was the restriction of the contextual manipulations to practice examples only, after the relevant principles and operations had been taught. Also, the simplicity of the contexts with regard to length and detail probably reduced the meaningfulness and thus the interest value of the applications conveyed.

Despite the absence of performance effects, the learner control outcomes were revealing regarding common selection strategies employed and their relationship to learner differences. Consistent with previous studies (Carrier et al., 1985; Ross & Rakow, 1982; Tennyson, 1980), there was a general tendency by subjects to select minimal instructional support (less than two examples per rule). Given the generally low posttest scores, this tendency may reflect subjects' inability to gain an adequate understanding of the content from the examples. As Clark (1984) suggests, students tend to avoid high support options (and the extra effort entailed) when they expect to fail anyway. Another possible explanation is that, as a result of working in an experimental rather than actual learning setting, subjects may have had low motivation to prolong the task by selecting additional support.

Identifying effective uses of learner control has relevance to the practical problem of making CBI more adaptive for learners. Program-controlled adaptive strategies that systematically select learning resources for students can provide powerful instructional adaptations (e.g., Tennyson & Rothen, 1977; Park & Tennyson, 1986), but are very costly to develop due to the sophistication of the executive models needed to analyze performance and generate individualized prescriptions oriented to the learning task concerned. Another alternative is "advisement" or "coaching" in which students are given direction by the program about what resources to select, but are ultimately free to make their own choices (Tennyson & Buttrey, 1980). But to provide such advice, the program must somehow determine what is "adaptive" for the individual, a process that carries similar executive modeling requirements (and associated development costs) as program control.

A third, more practical alternative is to identify strategies that facilitate independent adaptive decision-making by learners. Suggestive evidence from the present study is that when learners could select problems themes that interested them, the number of examples they elected to examine significantly increased compared to the no-context group (a 54% increase) and was directionally higher compared to the combined thematic context groups (a 17% increase). This basic idea is consistent with current theoretical views regarding uses of interesting displays and subject matter to increase motivation and attention in CBI (Keller & Suzuki, 1988). It was also supported by subjects' attitude ratings and open-ended survey responses, with approximately 90% of the LC sample commenting on the motivational and/or learning advantages of choosing preferred problem themes. Such personalized properties can increase the motivational effects that learner control in general seems to have for students as a CBI design component (Kinzie & Sullivan, 1989).

The number of shifts in the quantity of examples selected across lessons was the only task outcome variable to relate significantly to posttest achievement. This correlational outcome could have been influenced by numerous intervening variables. One possiblity, however, is that subjects who varied their selections more frequently were making greater use of metacognitive strategies in assessing their needs on the lesson (Tobias, 1987). This interpretation suggests the possible benefits of orienting LC strategies to help students to gain greater awareness of their needs and appropriate study behaviors. An exemplary approach is to require LC students to repeat formative test items that they initially answer incorrectly (Kinzie, Sullivan, & Berdel, 1988). Consequently, they receive immediate confirmation of their errors, while knowing that they will be held accountable for learning the correct information before progressing on the task. As an alternative, explicit on-task advisement (e.g., Carrier, Davidson, Williams, & Kalweit, 1986) might be used to prompt students to reflect on their degree of understanding and to vary their selection of LC resources accordingly (e.g., "Are you understanding this section? Consider selecting additional examples if you are having any difficulty."). This type of advisement, though requiring additional empirical validation, constitutes a highly practical means of providing adaptive coaching in CBI lessons.

The present study is also one of several recent CBI studies (i.e., Carrier & Williams, 1988; Kinzie et al., 1988; Ross, Morrison, & O'Dell, 1988) that have identified reading ability as a relatively strong predictor of achievement. Although reading skills should certainly affect text comprehension from any presentation medium, the unique conditions and constraints of CBI text displays (the small display area, keypressing requirements, special formats, back- and forward-paging limitations, etc.) may exacerbate attentional or comprehension problems for the low-ability reader (see Hepner, Anderson, Farstrup, & Weiderman, 1985). Further research should focus on this issue and the possibility of designing practical LC options that allow individuals to vary text formats or content (e.g., as in Morrison et al., 1988) according to preferences or needs.

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Table 1

Total Posttest Mean Percentage Correct for Context x Instructional Support Treatments

	Instructional Support		
Context	Minimum	Maximum	Learner-Control
Education	30.6	24.4	25.9
Sports	24.0	28.8	28.1
Business	26.3	24.2	28.4
No-Context	27.5	27.5	27.0
Learner-Control	23.8	27.0	27.8

Note: Possible range of scores was 0-43

Table 2

Summary of Learner Control Context Rankings and Selections

	Initial Rankings		Lesson Selections		
			Overall	Male	Female
Contexts	M	Rfl	M	M	M
Education	1.70	.55	3.66	1.00	4.07
Sports	2.56	.24	1.88	4.33	1.42
Business	2.74	.11	.91	2.38	.68
No-Context	2.99	.11	1.61	.33	1.82

[a] Relative frequencies of #1 rankings.
[b] Means indicate average number of selections across the 8 lessons.

Title:

Frequency and Spacing of Drill and Practice in the Learning of Verbal Information Using a Computer-Based Drill

Author:

S. Del Marie Rysavy

Abstract

The purpose of this study is to determine an optimal schedule for the frequency and spacing of drill and practice in the learning of verbal information. Subjects for phase 1 were sixty-two 4th, 5th and 6th graders in a public elementary school. Using a computer-based drill which incorporated in its structure the findings of past research, the students each determined their own practice schedule over a period of two weeks. A pretest and posttest were used to measure the level of success of each student in learning the assigned items. Results suggest that two times through the optimized drill, one near the time of original learning and the other near the retention measure, are sufficient for maximal learning of the drill material. This conclusion will be tested in phase 2 of the study.

Frequency and Spacing of Drill and Practice in the Learning of Verbal Information Using a Computer-Based Drill

The purpose of this study is to determine an optimal schedule for the frequency and spacing of drill and practice in the learning of verbal information. In order to provide an optimal practice tool, the study is using a computer-based drill which incorporates in its structure the findings of past research.

Since computers entered the educational realm, drill and practice programs have been widely used (Gerlach, 1984; Siegel & Misselt, 1984; Davidson & Traylor, 1987). Some have considered drill and practice a poor use of the computer because it does not use many of the capabilities of the machine (Yates, 1983; Fuson & Brinko, 1985; Salisbury, 1985). Research has been conducted to compare computer drill and practice programs with more traditional methods. Results often implied that the computer and traditional drills yielded the same results (Fuson & Brinko; Jamison, Suppes & Wells, 1974; Campbell, Peck, Horn & Leigh, 1987). In these studies, the traditional drill was often made as alike to the computer drill as possible. This suggests that the medium itself does not make a significant difference in the effectiveness of drill and practice.

At the same time, performance gains and reduced amount of time were found in several studies (Kearsley, Hunter & Seidel, 1983; Kulik, Bangert & Williams, 1983; Suydam, 1984; Carrier, Post & Heck, 1985). Some studies also observed improved attitudes (Kulik et al; Chambers & Sprecher, 1984). The most consistent positive results of improvement in achievement were found for the learning disabled (Edwards, Norton, Taylor, Weiss & Dusseldorp, 1975; Jamison et al; Chambers & Sprecher; Suydam; Balajthy, 1984; Chadwick & Watson, 1986).

Over-all, computer based instruction has spurred research throughout the field of instruction (Kearsley et al, 1983). Characteristics of learners and how these affect the learning process are being studied. The computer's ability to respond to individual differences and to help to analyze them is being more fully realized. For drill and practice programs, aspects of individualization are accomplished through processes such as feedback, correction of errors, varying levels of difficulty, and maintenance of individual student records. For example, by keeping track of errors, the computer can strategically reintroduce missed items in order to maximize the probability of retention. Some of these features would be difficult to implement with more conventional means such as worksheets or teacher presentation. The computer-based research of today, then, is built upon results of earlier studies involving instructional methods administered with more traditional means. With the computer, however, more complex strategies can be used than in the past.

Some research has been conducted to study various features of drill and practice in order to determine what methods/ qualities are most effective. Among the topics researched are spacing and length of practice sessions, review of missed items, and type of feedback.

Spacing and Length of Practice Sessions

Reynolds and Glaser (1964) conducted research on the effects of repetition and spaced review in the learning of a complex task. The study demonstrated the relative ineffectiveness of massed practice following initial learning. There has been much evidence to suggest that short, spaced practice periods yield better results than long concentrated practice periods (Anderson, 1980). At the occasion of each practice period, the learning context is somewhat different (e.g. student's pre-knowledge of the material, time of day, surrounding conditions, etc.), causing the information to be encoded somewhat differently each time (Salisbury, 1984).

According to McGeoch (1932), forgetting is as much a function of the amount of time between use of the material as of the experiences which occur during the intervening period. Thus the optimal spacing of practice sessions would depend on many factors. Research has shown that spaced repetition does increase meaningful retention (Peterson, Wampler, Kirkpatrick & Saltzman, 1963; Ausubel & Youssef, 1965).

Gay (1973) studied the effect of the temporal position of reviews on the retention of mathematical rules. She experimented with placing a review either 1 day, 1 week, or 2 weeks after original learning. A test administered 3 weeks after original learning showed that temporal position was not a significant factor, though the retention of all review groups was significantly more than a no-review group. A second experiment compared two reviews, placing them 1 and 2, 1 and 7, or 6 and 7 days after original learning. Again, all groups retained more than a no-review group. She concluded that additional reviews are highly effective in terms of delayed retention, and are very efficient in terms of numbers of examples as well as amount of time spent on those examples. Peterson, Ellis, Toohill, and Kloess (1935) had shown that a second review is more effective than the first, and Gay's study found that one early and one late are better than two early and two late reviews; i.e. the reviews of 1 and 7 days after original learning resulted in significantly better retention than the reviews of 1 and 2 days after learning.

Merrill and Salisbury (1984) summarize research as indicating that several short spaced reviews are more effective than a few massed reviews. Goldenberg (1987) suggests studying this question of spaced practice, added to his optimized review schedule (explained in the next section), taking into account individual learner differences.

Review of Missed Items

When drilling verbal information, the learner can make errors. It is then necessary to review those items until they are learned correctly. Research has examined the question of how often and how soon to reintroduce a missed item.

Siegel and Misselt (1984) conducted a study involving a drill program on English-Japanese (transliterated) word pairs in which an increasing ratio review was used. Their results suggest that increasing ratio review techniques (e.g. after 1,3,5 intervening items) are more effective than traditional techniques (e.g. 1 later) or no review at all. They also concluded that a 1-later review is no more effective than no review, suggesting that a 2-3-5 or 2-4-6 review schedule may be more effective than a 1-3-5 review schedule.

Goldenberg (1987) studied the optimum number of intervening items that should be inserted after an incorrect response before a drop-off in memory occurs. He used the same subject material as Siegel and Misselt (1984). He concluded that the optimum position was after two intervening items, with the second recommended position being after three intervening items. Salisbury (1985) suggests that missed items reappear according to a spaced review schedule of up to three review positions.

Feedback

The study of Siegel and Misselt (1984), discussed in the last section, also used adaptive feedback techniques with discrimination training. This significantly reduced the number of discrimination errors on the post-test. In their feedback paradigm, the types of mistakes were divided into two types - an "out-of-list" error, when the learner's response is not an answer to another item in the drill list, and a "discrimination" error, when the learner types a response that is an answer to another item in the drill list. When the first type of error is made, the correct answer is provided. In the latter types, discrimination feedback is provided; i.e. the learner is informed of the correct response as well as what stimulus was responded to. For example, in a drill on the states and capitals, if the student types **St. Paul** (the answer to the stimulus **Minnesota**) instead of **Jefferson** (the answer for the stimulus **Missouri**), the feedback provided is "the capital of Missouri is Jefferson; St. Paul is the capital of Minnesota."

Salisbury (1985), in describing what he considers "good" drill and practice strategies, includes discrimination training as one of the features of the strategy.

Observation

The many student differences which can affect success in various learning strategies can make it difficult to come to clear-cut conclusions regarding aspects of computer-based instruction. Tobias (1981), in a discussion of adapting instruction to individual difference among students, suggests that research might be begun by observation of what students of varying individual difference characteristics actually do, and what instructional options they select. From this observation, the researcher can then generate a prediction as to what strategy might be best for them.

Observation is the method used in phase 1 of this study. In order to first obtain additional data from which to propose and test a review schedule, the study is being carried out in two phases. The data obtained through observation in phase 1 (already completed) is being used to determine a schedule which will then be tested in phase 2. This report includes the results from phase 1.

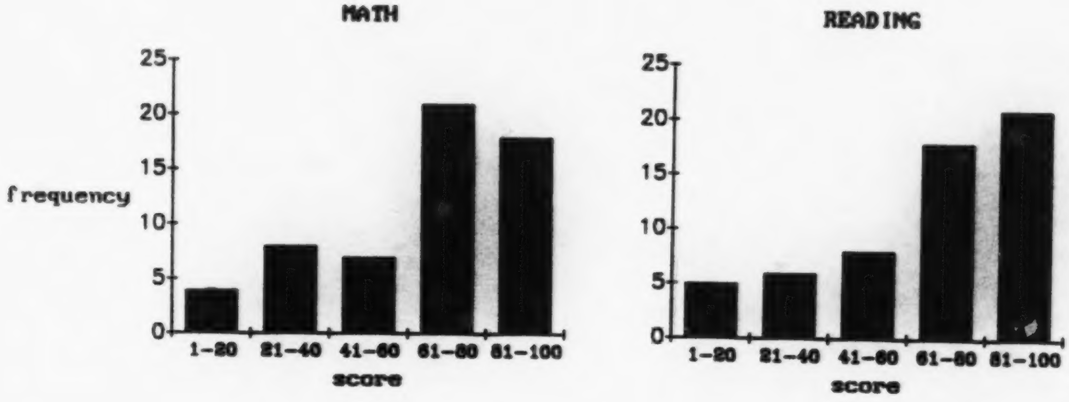
Methods

Sample

Students involved in phase 1 of this study were the sixty-two 4th, 5th and 6th graders in an urban Minneapolis public elementary school. Absenteeism was the major reason for a student's not being able to participate fully in the study. 55 students (89%) took the pretest, 58 (94%) used the computer drill, and 61 (98%) took the posttest. 51 students (82%) participated in all three parts of the study.

Data was obtained from the school files on CAT exams taken in the fall of 1988 by 58 (94%) of these students. Math concepts and math computation results were averaged to obtain a math score. The group mean for math is 66.1 with a standard deviation of 25.8. The mean for reading is 67.6 with a standard deviation of 26.8. These math and reading scores were obtained as a measure of ability in order to observe whether better choices (leading to better success) would be made by students of higher ability. Figure 1 shows the frequency distribution of the math and reading scores.

Figure 1: Frequency Distribution of Math and Reading CAT Scores



Materials

The teachers of these students were consulted to determine which verbal information would be used for the study. This was done so that the drill might enhance regular classroom procedures rather than interfere with them, and so that the material used would be a part of the students' program of study. The resulting drill involves the naming of the capitals of the 50 states of the United States.

A computer-based drill program was developed for use with this verbal information. The findings of research, as described above, were utilized in the designing of the drill in the following ways:

1) Feedback includes discrimination feedback; i.e. when a student answers incorrectly with another response from the list, both the correct answer and the stimulus for which their response should be given is indicated. If the response is not in the list, only the correct answer is given. After correct answers, a counter is incremented and the next item appears.
2) Once an item is missed, it is reviewed three times with the following schedule: after 2 intervening items, after 3 more intervening items, and then after 5 more intervening items. If it is missed again, this pattern is begun over. If two items are cued to the same position, the item most recently incorrect is placed first.
3) If an item is answered correctly the first time, or if it has passed through a review schedule with no further errors, it is moved to the review pool. In this way the size of the working pool is controlled.
4) The drill session can be ended at any time. This allows the student to decide the amount that he/she studies at one time. This is a second way of controlling the size of the working pool.
5) Records are kept of each practice session. Therefore, if a student stops before completing the entire list of items, at the next session the program continues where it left off.

The drill was reviewed by four persons (one professor, two adults, and a teacher of the sample group) who suggested editorial changes which were incorporated into the program before it was used by the students.

Pretest and Posttest

The pretest and posttest consisted of a random listing of the 50 states for which the students were asked to give the capital. Both tests were paper and pencil tests, as a sufficient number of computers were not available for administration to a large group.

Procedure

At the beginning of the first week, the material was assigned and the written pretest was given. The computer-based drill was demonstrated to the students and the other details involved in using it (location, procedure, etc.) were explained. The students were given two weeks for the learning of the material, at the end of which the written posttest was administered. The choice of when and how often to practice was left completely to the student. The computer recorded each practice session and its results. Each student had a folder on file containing a diskette with the drill program, and a paper which served as a backup to the information recorded by the computer. On the paper, the student recorded the results (number tried, number correct, number remaining) on blanks arranged according to the date of the practice.

Results

Data Collected

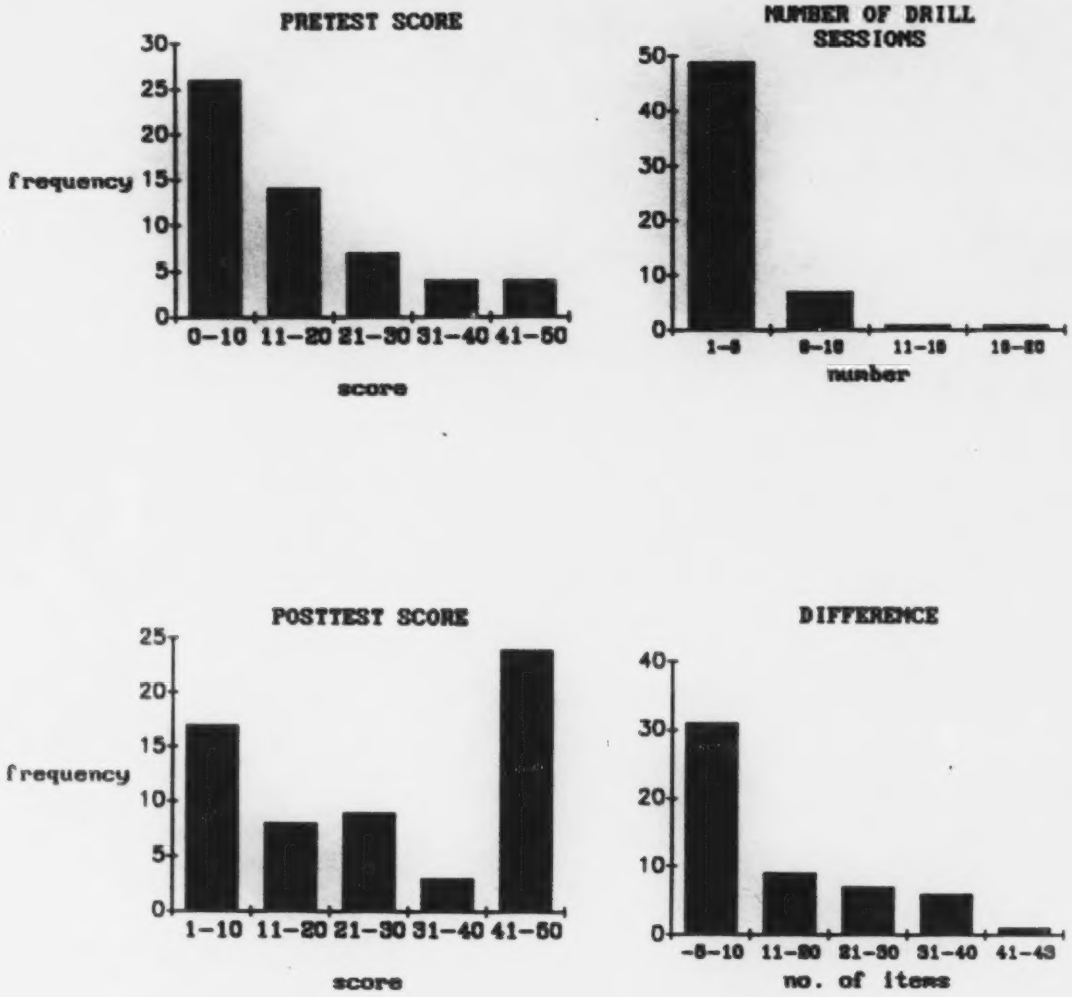
Pretest scores ranged from 0 to 43 ($\underline{N}$= 55, $\underline{M}$=14.47, $\underline{SD}$=12.8) out of a maximum of 50. For an item to be considered correct, it had to be spelled correctly. This was consistent with the computer drill, in which an answer was not considered correct with improper spelling.

During the two-week period, the length and number of practices were affected by computer availability, absenteeism and classroom schedule. Student use of the drill thus ranged from 0 to 17 sessions, with a median of 2 sessions ($\underline{N}$= 62, $\underline{M}$=3.13, $\underline{SD}$=2.9). Length of practices also varied widely, from an individual student average of 5.5 items per session to an individual student average of 148 items per session ($\underline{Mdn}$=33.5).

At the end of the practice period, posttest scores ranged from 1 to 50 ($\underline{N}$=61, $\underline{M}$=27.54, $\underline{SD}$=18.15). The resulting difference scores (posttest minus pretest) ranged from -5 to 43 with a mean of 12.4 and a standard deviation of 12.28.

Figure 2 shows the frequency graphs of the above variables.

Figure 2: Frequency Distribution of Descriptive Variables



Fifty-one of the students (82%) took both the pretest and posttest and used the drill during the 2-week period. All of the remaining statistics refer to this group.

New Variables Computed

Because the length of practices varied widely, a variable was created to indicated number of items tried as another way of quantifying amount of practice. This variable, which counts an item each time it is encountered, ranges from 7 to 436 items tried (M=122.43, SD=112.4).

A third variable used to quantify amount of practice was the number of times a student completed the entire drill. It ranges from 0 to 6 with a mean of 1.19 (Mdn=.54) and a standard deviation of 1.45.

To quantify the student's success in learning unknown items, the difference between the posttest and pretest scores was divided by the number each student needed to learn (50 minus the pretest score), creating a percentage of "success" in learning unknown items. It ranged from -.12 to 1.00 (M=.43, SD=.39).

A variable was created to compare practice with success. It was obtained by dividing the number of items tried by the number of items learned. Thus, it indicates the number of items tried per each item learned. It ranges from 0 to 148, with a mean of 13.95 and a standard deviation of 21.9.

A final variable was created indicating when the student practiced. The coding was E (early) for those who practiced only the first week, L (late) for those who practiced only the second week, and B (both) for those who practiced both weeks.

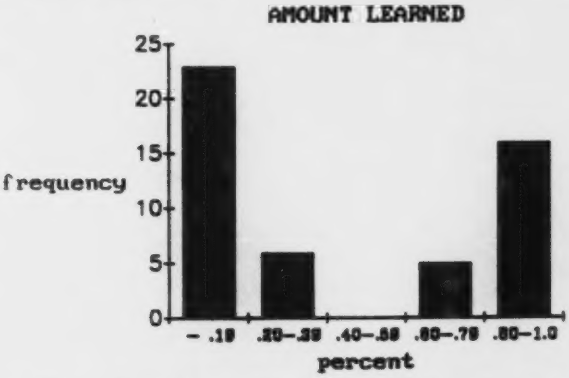
Statistical Procedures Used

The frequency graphs of the math and reading scores indicate that the ability level of the sample group is not normally distributed (see Figure 1). There are various opinions as to which tests should be used with such samples. For this reason, both parametric and non-parametric tests were used for many of the statistical procedures. In all cases, basic conclusions were the same, with differences being found only in the strength of the results. For example, regression analysis on the rank scores resulted in more conservative figures than regression on the raw scores. The non-parametric values are reported in this paper.

Comparison of Two Groups

22 students learned 60% or more of their unknown items, and 29 learned 38% or less. The distribution of AMOUNT LEARNED is shown in Figure 3.

Figure 3: Frequency Distribution of Amount Learned



Since the goal for the students was to learn all the states and capitals, the 22 students who learned at least 60% of their goal were considered "successful" (S), and the other 29 were considered "unsuccessful" (U). These groups were then compared in order to observe what may have determined their level of success.

The Wilcoxon rank-sum test was used to identify significant differences in means between the S and U groups. As shown in Table 1, the means of several variables varied significantly between the two groups.

Table 1: Comparison of Means of S and U groups Using the Wilcoxon Rank-Sum Test

	MEAN		p-value
	S	U	
math	82.08	55.80	.0002
reading	76.70	60.54	.0170
pretest score	22.09	9.56	.0001
number of sessions of practice	4.46	1.75	.0001
number of times through the drill	2.28	.32	.0001
number of items tried	207.32	52.59	.0001
posttest score	45.96	14.16	.0001
difference (posttest minus pretest)	23.86	4.53	.0001

These results indicate that the successful group practiced more times, completed the drill more times, and tried more items than the unsuccessful group.

One variable did not differ significantly between groups, and that is the number of items tried per each item learned (p=.7973). The mean of this variable for the combined groups was 13.95. This suggests that it may be possible to quantify the amount of practice needed in order to learn an item.

Agreement with Previous Research

Although no control was made for effects of the pretest results on student choices, data from this study appears to agree with previous research regarding the time of practice, as discussed on page 4. The students who practiced both weeks (both early and late) numbered 23, and learned an average of 65% of unknown items. The students who practiced late (N=14) learned an average of 36%, while those who practiced early (N=12) learned an average of 19%. None of the successful students (S) practiced only during Monday-Wednesday of the first week. Likewise, none of the students with a success rate less than 10% (N=11) practiced both weeks or at the end of the second week.

Predictors of Amount Learned

Spearman rank order correlation coefficients were run on pairs of variables to note any strong relationships between them. These results are reported in Table 2.

Table 2: Spearman Rank Order Correlation Coefficients Between Variables

Variables	No.Times Through Drill	No.of Items Tried	Percent Learned
Math	.36	.33	.44
Reading	.34	.28	.31
Pretest	.47	.34	.53
No. Times Through Drill		.92	.76

Spearman Rank Order Correlation Coefficients of .37 or more have a p-value of .01 or less. Those of .28 or more have a p-value of .05 or less.

The r-values suggest that success correlates more with the number of times through the drill than with number of items tried. The strong relationship between number of times through the drill and number of items tried results from the fact that they both measure amount of practice. The r-values in the first two rows of the table suggest that ability level (as provided through the math/reading CAT scores) was not strongly correlated with the choices made by the students.

Regression analysis was performed with the amount learned (percentage of success) as the dependent variable, and with pretest score and the number of times through drill (or number of items tried) as independent variables. The number of times through the drill contributed 58% of the variance and the pretest added another 4% (p=.03). The other combination (pretest, number of items tried), yielded an R^2 of 59% (p=.001).

A second analysis was done with the same variables, but first controlling for the effect of the pretest score. The pretest score explains 28% of the amount learned (p=.0001). After the effect of the pretest score is removed, the number of items tried explained 38% of the amount learned, while the number of times through the drill explained 36.5% of the amount learned (p=.0001 for each).

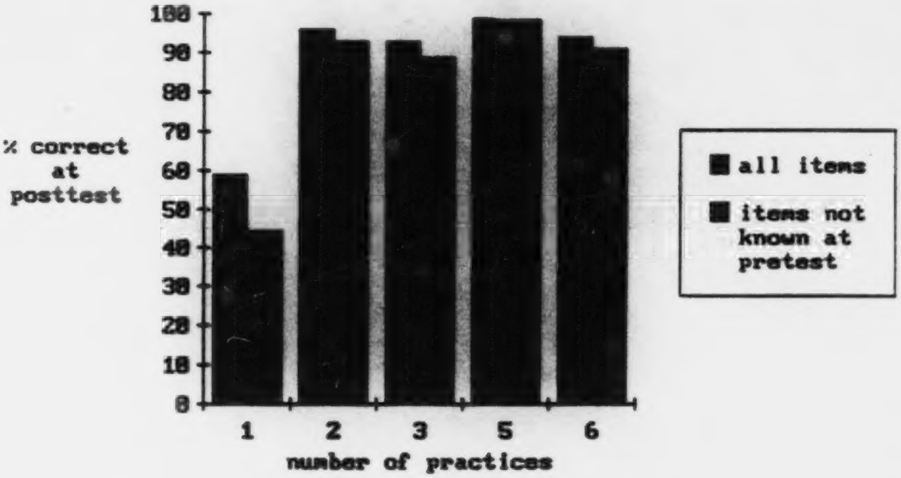
Item Analysis

The computer recorded the status of each item at the end of a practice session. In this context, an item was considered as practiced once either when it was answered correctly and thus encountered once, or when it was missed and therefore repeated 3 times. This information was studied item-by-item in order to observe at what point an item appeared to be learned by the student. Since 30 of the 51 students did not complete the drill even once, many of the items were not practiced at all.

With 51 students potentially practicing 50 different items, there was a total of 2550 items to consider. Forty-two percent (1065 items) were not practiced at all. Of the remaining 1485 items, 58% (861 items) were practiced once, 15% (218 items) were practiced twice, 17% (256 items) were practiced 3 times, 7% (100 items) were practiced 5 times, and 3% (50 items) were practiced 6 times.

The percentage of items correct on the posttest after the various number of times of practice was calculated. Percentages were calculated on all items, as well as on those which were not known at the time of the pretest. These results are shown in Figure 4.

Figure 4: Percent of Items Correct After Practice



From this graph, it is possible to see that once an item was practiced twice, it was about as likely to be answered correctly on the posttest as if it were practiced more than twice (whether it was known at the pretest or not). This suggests that two times through the drill may be sufficient for learning most of the items.

Using average figures from the data on each item practiced, it was possible to approximate the number of items tried per each item learned while completing the drill twice, as follows: The average "student" (out of 50 states and capitals),

had 19 correct on the pretest
knew 29.5 after the first practice (based upon the data on items practiced only once)
had 37 correct on the posttest,

thus learning 18 items.

During the first practice, this "student" would have tried the 19 problems once each, and tried 31 problems 4 times each, for a total of 143 items encountered. At this point, he/she knew 29.5 items. During the second practice, 29.5 items were tried once and 20.5 items were tried four times, for a total of 111.5 items.

After two practices, then, the average "student" had tried 254.5 items. Since he/she learned 18 items between the pretest and posttest, he/she tried 254.5/18 or 14.14 items for each item learned. This figure is comparable to the actual mean of 13.95, as calculated from the student data. This fact suggests that both the item-by-item analysis and the variable "number of items tried per each item learned" are indicating that practicing an item two times with the procedures used was sufficient for learning most of the drill material.

Discussion

The purpose of phase 1 of this study was to obtain data from which to propose an optimal schedule of review for the learning of verbal information. The following are the conclusions drawn.

The ability level of the students, as indicated from their CAT scores, did not seem to strongly affect the choice, and thus effectiveness, of their practice schedule. (The highest *r*-value was .36 between the math score and number of times through the drill, as seen in Table 2.) The math and reading scores were therefore not used for further analyses.

The number of times through the drill was the strongest factor for predicting the success of the student. This was demonstrated both in the correlation and the regression analyses, as well as in the item-by-item analysis. The item-by-item analysis suggests that *two* times through the drill is sufficient. Since those who practiced both early and late in the two-week period were more successful, the two practice sessions should be scheduled accordingly.

The conclusion of this phase of the study, then, is that for the learning of verbal information, when an optimized computer drill (with discrimination training and an increased ratio review of 3 positions for missed items) is used with placement of reviews early (near the time of original learning) and late (near the retention measure), then the two practice sessions are sufficient. In phase 2, these conditions will be tested in comparison to practice strategies in which the review of missed items and/or the scheduling of practice sessions are altered.

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Title:

Can CAI be more Effective for Teaching Johnny than Traditional Instruction - Why have Studies been Inconclusive?

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ABSTRACT

Computer-assisted instruction (CAI) first became a major area of interest during the 1960s, partially because equipment and software costs had moderated by that time, and partially because federal funds became available to support some of these applications in certain settings. Interest in CAI has continued to escalate as microcomputers have become more available and as more software for these applications has also been developed.

With the advent of microcomputers (such as Apple II, IBM PC, TRS-80, and Commodore PET) research in K-12 and colleges greatly increased since 1975. These studies were designed to determine the general effectiveness of CAI to the best method of textbook or other specific characteristics of CAI. These studies were conducted in three main settings: computer laboratories, remedial instruction, and non-remedial instruction.

This paper reviews empirical studies of the efficacy of CAI use in various settings, with particular attention to the use of CAI to teach mathematics skills and concepts. Studies using various ages of students and subjects are considered, and are applications in which CAI was used as the primary instructional vehicle as against studies in which CAI was used as a supplement to conventional instructional intervention. These studies are used to discuss design flaws in CAI research studies. Recommendations are suggested for improving CAI study designs. Alleviating the design flaws might actually show differences in achievement not yet seen but in a few studies.

In general, CAI has been found to be at least as effective as conventional instructional methods, but superiority of CAI has been demonstrated in only a limited number of studies. Failure to find statistically or educationally significant results favoring CAI may, in some cases, be an artifact of small sample size or other design flaws. CAI appears to be most useful when software includes diagnostic branching that attempts to detect the conceptual difficulties that students experience when confronting certain problems, and then presents instructional activities that focus on individual student needs.

Can CAI be more Effective for Teaching Jonny than Traditional Instruction - Why have Studies been Inconclusive?

The 1960s was the initial introduction of computers into education. Pioneered by IBM and Philco-Ford, computer-assisted instruction (CAI) was developed and brought computers closer to being in the classroom. In the late 1970s, inexpensive computers, such as the Apple II, TRS-80 model I, and Commodore PET, were available for K-12 schools. This began a trend toward deveolping vast numbers of CAI programs and CAI research.

As software has developed, a reorganization of thinking of what a computer can do has emerged. Gellespie (1981) discussed the computer being considered a "tutor" that could provide endless practice, present alternative paths, provide self-pacing, and ask many questions in a variety of formats. The computer also has other advantages, such as presenting the same material to many students simultaneously while serving the needs of the individuals.

Since about 1962, researchers have explored the effectiveness of educational software in the schools under various conditions. Zinn (1965), Wold and Hunter (1984), and James (1986) have argued that CAI is effective for instructing students. But, many studies that these authors reviewed to draw their conclusions had design flaws. In addition, meta-analyses have been performed which contend that CAI is at least not harmful and probably effective (Burns & Bozman, 1981; Hartley, 1978; Hasselbring, 1986; Kulik, Bangert, & Williams, 1983).

Computers have become part of the school environment. This is evidenced by the tripling of the number of computers used for instructional purposes in K-12 schools during the first half of the 1980s. In light of the expanding availability of computers, several questions have arisen. First, is CAI a viable method to effectively instruct independently of other instruction? And secondly, why have previous studies been inconclusive about the effectiveness of CAI?

Viability of CAI to Instruct

In the past few years, there have been many educators arguing that CAI is effective for instructing students (James, 1986; Wold & Hunter, 1984; Zinn, 1965). These authors describe the types of instructional programs, the development of the software, and even how to use the software. What is lacking is information describing the successful implementation of the software with student achievement improved. Most articles relate to the viability of CAI as a supplement to classroom instruction or independent of classroom instruction. But the fundamental question is can CAI aid student learning? The follow-up questions include: whether some program are effective and othere are not; and how should CAI and computers be used within the curriculum?

Computer Laboratories

Several studies have explored the effect of computer labs in which students "experiment with concepts or applications or explore repeated applications of course content" (Sterrett and Karian (1978, p. 114). Sterrett and Karian (1978) used a statistical laboratory in an introductory non-calculus statistics course. The 35 students in two statistics classes were given accounts and data sets to explore the concept of statistical significance. Sterrett and Karian (1978) found that the use of this lab "enhanced the students' ability to understand the nature of experimental results and statistical reasioning" (p. 1116). But, statistically significant nor educationally significant results were found.

Lang (1973) employed CAI as a supplement to introductory calculus course instruction. The CAI supplemented the class work of 19 students, with additional homework assignments intended to reinforce several topics taught in class. The 15 non-CAI students received similar homework assignments concerning the same topics, but without the use of the computer. Lang (1973) found that concept attainment was enhanced with the use of CAI. Lang (1973, p. 5662A) concluded that CAI has the potential to be "an effective means of improving the students' understanding of the basic concepts of calculus". No statistical significance was found for achievement even though that broad conclusion was made.

In 1975, Calswell and Polley created a computer lab which presented students with practice problems with randomly generated problem parameters. The students solved the problemss and entered the solution into the computer. The computer would diagnose the solution, if it was incorrect, and match an error to the answer. Caldwell and Polley (1975) found that this diagnosis was helpful to some students, but did not eliminate the need for other types of instructional aids.

These three studies illustrate that computer can, with at least moderate success, supplement traditional instruction. But, from these studies, computers seem an improbable solution for eliminating the need for teachers or for other instructional aids.

Remedial Instruction

CAI has also been employed for remedial instruction. CAI has been used both as a supplement to traditional instruction as well as the sole means of instruction for remediation. During the 1970s, many educators felt this was the dominant role that CAI should take.

Sherman (1975) conducted a project evaluating the use of CAI to remediate the multiplication and division skills of college students. Sherman selected all students scoring zero percent on a diagnostic test. The 35 experimental group students received CAI while the 82 control group students received "traditional" lecture on the same material. Sherman (1975) found that CAI successfully facilitated student achievement on all insstructional objectives.

In 1984, Glidden, Harrald, Hodges, and Kunec supported the conclusion made by Sherman with Coast Guard entrants. These researchers reported statistically significant treatment effects as measured by the Armed Forces Vocations Aptitude Battery.

Imboden (1985) studied the effects of computer enhanced instruction on low achieving college students learning the concept of percent. Thirty-eight subjects in the freshment through junior year were assigned to either the experimental group, computer enhanced instruction, or the control group, lecture method, with both groups covering the material to essentially the same degree. Imboden (1985) found that the computer enhanced instruction appeared not to be different from the lecture method.

These studies highlight that CAI is a viable means of presenting material for remedial instruction. All of the studies discussed used the CAI for sole instruction but also had a narrow focus. No studies were found that used CAI for remediation and used it as a supplement to "traditional" instruction. This indicates a gap in the research.

Non-Remedial Instruction

The use of CAI as a means of non-remedial instruction has been the foucs of various studies involving students from elementary to post graduate educational levels. Research ranges from the investigation of using CAI to teach specific topics to using CAI to teach the entire course. Two recent studies illustrate the use of CAI to teach an entire course.

Enochs, Handley, and Wollenberg (1986) used a stratified random sample dividing 50 U.s. Navey Yoeman "A" students into two groups: "those taught traditionally in self-paced mode and those taught via CAI" (p. 136). Enochs et al. (1986) found that there were statistically significant differences in achievement gains across groups which favored the CAI group.

Ozarowski (1973) investigated the use of CAI in college statistics classes. Ozarowski (1973) assigned 23 subjects to each group, experimental and control, by matching. The students covered the same material normally undertaken in a basic statistics course. The researcher found that the time taken to complete the course was statistically significant less when the computer method was used rather than the conventional classroom method of instruction. Learning gains were also statistically significant in favor of the students being instructed by the computer (Ozarowski, 1973). These results are even more noteworthy given the relatively small sample size.

The studies by Encohs et al. (1986), Imboden (1985), and Ozarwski (1973) indicate that CAI is at least as effective as "traditional" instruction when CAI is used to teach an entire course. There is also evidence that CAI is better than "traditional" instruction in the length of time students need to learn material and the achievement level.

As a note, there are numerous CAI studies conduct with one to five topics. Thse studies show nominal achievement gains in favor of CAI, but never statistically significant differences. The lack of statistical significance are due to the small sample sizes, but even a greater problem is the shortness of the study. Thus, there may be more effectiveness in CAI than these studies can ever determine because of design flaws.

Design Flaws in CAI Studies

Reviews of educational software effectiveness (Chambers & Sprecher, 1980; Colorado, 1988; Schmitt, 1987; Schmitt, 1989) studies have noted four major research design weaknesses: small sample sizes, lack of identified criteria for determining "quality" software, inappropriately used statistics, and inadequate time allocated to conducting the study. Because the actual studies have design flaws, these research design weaknesses will be reflected in the results of the studies and even compounded should meta-analyses, using these studies, be performed since meta-analyses are analyses of an analysis of data.

This section discusses these four major weaknesses in many CAI studies. Sixteen studies are used to illustrate the design weaknesses frequently found in CAI research but is also common in other educational research endevors.

Selection of Research Studies

Several sourses of educational papers were surveyed, ERIC, Dissertation Abstracts Internation, and educational journal, from 1970 through 1987. Sixteen CAI studies in mathematics published during this 17 year period were randomly selected to be used to illustrate the research design weaknesses in CAI studies.

The appenidx has a table lists the various characteristics of CAI studies in mathematics. This table present the sample size, the length of the study, the software used (commercial, public-domain, self-made, or unknown), the statistical procedures employed, and the conclusions (more effective, no difference, less effective) with traditional instruction.

Small Sample Sizes

One controlable research design aspect is the sample size. The second level questions the researcher asks are:
Who is my population?
Who will be in my sample?
And, how many people will be in my sample?
These three questions usually follow the definition of the research problem and development of the research questions. Tables and/or formulas can be found in any number of social science statistics books to determine the sample size required to have sufficient "power" for the study.

CAI researchers like many other educational researchers neglect sample size. The mean sample size in these 16 CAI studies reviewed was 74. This is the sample size for the entire study, not just a level of a way. Difficulty achieving statistical significance is suprising due to this fact. Most CAI studies do not have sufficient "power". Not only are these studies not statistically different, but if educational significance is explored, through effect sizes, many of these same studies do not indicate educational significance in the findings. This is also supported by conclusions by (Colorado, 1988; Schmitt, 1987).

As examples of small sample sizes, Pachter (1979) used a sample of 29. Other studies using a sample size in the thirties were Sterrett and Karian (1978), Lang (1973), Robichaud (1986), Imboden (1986), and Wilson (1986) with samples between 29 and 38. Three studies did have large samples: Goodson (1975) with 93, Sherman (1975) with 117, and Shapiro (1977) with 400 subjects.

There are solutions to this problem. Instead of using a single school and one grade level, the researcher could use two schools. One school could be the control group and the other could be the experimental group. If more than two groups are needed expand the number of schools. This would increase the sample two fold or by the number of research groups needed for the study.

A second solution would to take multiple schools and have all of the research groups microcosums of the research study. Instead of having three schools, each school representing a different group, have each school have the three groups thus amounting to a similar sample size as the above suggestion.

A final suggestion would have several researchers from different school districts or states work on the same study. Each researcher would have all the groups in his "sub-study". This would not only increase the sample size but also the generalizability of the study.

These soultions are just three logically thoughout solutions to the problem of sample size. This author feels that one of the major reasons statistical and/or educational significance has not been found is due to sample size. The lack of greater effectiveness over traditional instruction has hindered the expanded use of CAI in some form of classroom instruction. The findings of these past studies has also hindered the further investigation of CAI effectiveness similar to the past and in other aspects.

Duration of the Study

The duration of the study is usually largely under the control of the researcher. Although, the availability of students and the liberties schools and teachers give researchers may be constraining, the researcher does have a reasonable amount of control over how long the study will take place.

The second design flaw found in many CAI research studies is the length of the study. Several of the studies (i.e., Imboden, 1986; Shine, 1983; Pachter, 1979; Goodson, 1975) only lasted through one topic. In science and mathematics, a topic may last one to three days. This limits the study to the length of time the single topic is discussed. Other studies lasted through multiple topics. Finally, there were some studies that lasted a semester or longer: Sterrett and Karian (1978), Lang (1973), Crenshaw (1983), and Ozarowski (1973).

The length of time is largely determined by the number of software packages are used in the study. On one dimension there are the topics that will be included in the study (i.e., solving linear equations, long vowels, the solar system). On another dimension, usually neglected, is the variety software package types that can be used (i.e., drill and practice, tutorial, simulation and demonstration, games). The studies report the topics and usually only employ one type of software package. A more accurate deption of how effective CAI is on a given topic might be to use several differnt software types on the same students or on different student and observe differences.

Even those studies which lasted a semester, the students may have only had limited use of the computers. Use once a week or every other week could possibly not show differences as much as using the computers twice or three times a week throughout the semester.

This is not to say that the general duration, a semester or even multiple topics is not long enouth, but this author is suggesting that actual computer usage would be a better indicator. CAI studies have varied from students using the computer 15 minutes per session to one hour per session. The duration of the sessions makes a dramatic difference when discussing ten 15 minute sessions compared to ten one hour sessions.

Additionally, if the sessions are distributed over various topics and multiple software types are used, there is more likely to be statistical and/or educational significance. The length of the study most definitionally has an effect on either measure of significance. And obviously, the results will also be more stable over time and over software types. This may also produce more generalizable results.

Software Quality

The lack of knowledge of the software quality or the lack of quality software used is considered an inexcusable design flaw. Educational software quality ranges from abonable to excellent (Allen, 1984; Bitter, 1984; Burke, 1982; Jensen, 1985; Kamil, 1984; Komoski, 1987; Lathrop & Goodson, 1983; Staples, 1985; Taylor & Ely, 1987). Staples (1985) has stated that there is a tremendous amount of variation in the quality of software, but the largest quantity is the poorer software. With the amount of poor quality software, the "educational merits of [software] packages need to be questioned" (Niman, 1987, p. 57).

All of the studies reviewed either did not state what software was used or defined the software as made by the researcher (self-made). There was no discussion in any study pretaining to the quality of the software. This is disturbing since one major criticisms of CAI by teachers is that "there is no good software out there" (Balajthy, 1988, p. 51).

The quality of the software is the backbone of all CAI studies. If the software is not excellent or at least good, then CAI may be found to be ineffective or at least as effective as "traditional" instruction. The quality or lack there of in the research software is compounded by the previous two flaws, particularly the duration of the study.

The major concern for this author is not so much that the researchers developed the software for the study, but that the quality of the software was not documented. This is particularly a concern in those papers from ERIC since there is no page limitations.

Suggestions for documenting the quality of software whether it may be commercial, public-domain, or self-made. First, if the software being used in the study was commercially produced, check in ERIC or subject matter journals for reviews of the software (i.e., MicroSIFT, Alberta, Arithmetic Teacher, Mathematics Teacher, English Teacher, Reading Teacher, Science

Teacher). Second, if the software was not commercially produced, locate a software evaluation instrument (i.e., MicroSIFT, NCTM, NCTE, or other published in ERIC or various journals). Third, provide documentation from referencing the review found or a summary of the software evaluation. Finally, discuss reason for using particular software particularly if the software was self-made and/or received a poor review or evaluation.

It is this authors opinnion that the major downfall of past CAI research studies has been the lack of quality software. This has placed both CAI research and the use of CAI software in jepordy. Without credible software research studies will fail to accurately determine efffectiveness or ineffectiveness of CAI.

Statistical Procedures Employed

To this point, most studies have relied on univariate statistics. The predominant statistical procedures employed have been analysis of variance (ANOVA) and t-tests. In and of themselves there is nothing wrong with these statistical procedures, but they have been misused and overused.

The three statistics that were used by all of the reviewed studies were ANOVA, t-test, and regression. Given the data, the general type of statistics used was appropriate. One problem is that in several studies, multiple ANOVAs and multiple t-tests were employed. This is problematic.

The same logic used by textbooks supporting the use of ANOVA tests over t-tests can be made for using multivariate statistics over multiple ANOVAs. If the alpha is set at .01, with one ANOVA there is a 5 percent chance that the test would be declared statistically significant (Asher, 1976). This is termed experimentwise Type I error.

When more than one ANOVA, or any other univariate test, is performed on the same dependent variables the experimentwise Type I error probability is increased exponentially. This error can range from the set alpha level, when all of the dependent variables are perfectly correlated, to "1 - (1 - alpha) raised to the k power, where k is the number of statistical test conducted" (Thompson, 1986, p. 6), when all of the dependent variables are perfectly uncorrelated. The most troubling fact is that except at the two extremes, the actual experimentwise error rate cannot be readily determined (Thompson, 1986). The result is a greater probability of statistical significance (McMillan & Schumacher, 1984; Sowell & Casey, 1982). Thus, instead of multiple univariate statistics, one multivariate statistic should be employed.

But beyond the fact that the probability of statistical significance is greater, multivariate statistics also better represent the reality of the classroom. And, the classroom is where the CAI will be used. Thompson (1986) argues that the statistical procedures should be as complicated as the environment in with the data was collected. The classroom is not simple. And, there is not one dependent variable that is involved. Achievement, interest, and attitude are just three aspect that are involved in all learing, whether or not the computer is used. These three aspects, and possibly others, need to be assess together and not independently. Additionally, differet aspects of achievement should not be investigated independently, but together as well.

CAI research, like much of educational research, has neglected the need and usefulness of multivariate statistics. Univariate statstics can be used. And there are appropriate situations. But, when multiple univariate tests need to be employed, multivariate tests are then most appropriate.

Finally, educational significance or effect sizes has been neglected throughout CAI research. An effect size, often R , is used to determine educational significance. One of the easiest effect sizes to calculate is (sum of square explained divided by sum of squares total) . Even is there is no statistical significance, especially with a small sample size, there may be educational difference. And obviously, the higher the percentage of difference the greater the difference.

Design Flaws Affecting Meta-Analyses

Simply put, meta-analysis is the "analysis of analyses" (Glass, 1976, p. 3). Basically, meta-analysis is the reviewing of a collection of studies to summarize statistics (Kulik & Kulik, 1988). Kulik and Kulik (1988) explain that meta-analysis is not based on statistical significance by effect sizes and the strength of relationships.

Because meta-analyses rely on other studies, the meta-analysis study incorporates any problems the reviewed studies might have. Thus, CAI meta-analyses also incorporate the flaws described above. Most specifically, length of the study and the quality of the software. Due to the use of effect sizes, the sample size does not influence the meta-analysis as much as if statistical significance was investigated, since statistical significance is largely a product of sample size.

The flaws of the studies do influence the results of meta-analyses. This compounds the problems since many educators rely on the meta-analyses as the literature for the effectiveness of CAI because of the vast numbers of CAI studies. The meta-analyses can provide a false sense of success with CAI that has not been shown to necessarily be present in CAI studies.

Summary

There are design flaws with past CAI effectiveness studies. After reading a few studies this conclusion seems obvious. But, all is not lost. If researchers heed the recommendations for improving CAI studies there may be some hope.

As the technology of computers grows and the demand for computers in schools from within the education profession and from parents increases, there needs to be accountability that CAI is useful, effective, and necessary. Unless there are sound research studies to backup the use of CAI, it will fall like a dead duck.

CAI may not be effective as the sole means of instruction, but that does not mean it is not useful and necessary, the jury is still out. But, CAI does seem viable for remediation and long self directed courses. The CAI researchers need to provide the fuel to spark the demand for quality CAI and appropriate uses of the software.

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APPENDIX
TABLES OF STUDIES

Table 1. Mathematics Studies

Author(s)	Sample Size	Duration of Study	CAI Software	Statistics
Rockhill (1971)	53	4 topics	self	T-tests
Schoen (1972)	60	Semester	self	ANOVA
Lang (1973)	34	Semester	self	ANOVA
Ozarowski (1973)	46	Semester	self	T-test, ANOVA
Goodson (1975)	93	1 topic	self	ANOVA
Sherman (1975)	117	Semester	self	ANOVAs
Shapiro (1977)	400	Semester	self	ANOVA
Sterrett & Karian (1978)	35	Semester	self	ANOVA
Pachter (1979)	29	1 topic	self	T-test
Crenshaw (1983)	43	Semester	CCC	T-tests
Shine (1983)	41	1 topic	self	ANCOVA
Walker & Azumi (1985)	153	5 months	MATH1-6 program	T-tests, regres.
Enochs & others (1986)	50	Semester	self	ANOVA, Pearson
Imboden (1986)	38	1 topic	self	ANOVA
Robichaud (1986)	32	Semester	self	T-tests
Wilson (1986)	38	6 topics	self	T-tests

mean sample size 79; standard deviation 92.3
mean sample size without Shapiro 57; standard deviation 35.8

Note. CCC is Computer Curricular Corporation System

Title:

The Interplay of Interactivity and Motivation in Educational Software

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This work explores the interplay between various types of software interactivity and a program's motivating elements. It is our hypothesis that children bring specifiable expectations to their interactions with educational software. These expectations, to a large extent, will determine which features of a given program will be motivating to a child. Additionally, the different genres of interactivity relied upon by software designers will elicit different expectations from a child and may resonate or conflict with the motivating elements built into the program. The state of affairs for the designer of educational software is much like that for the movie director. The director of a certain genre must include the elements the audience comes to see (e.g., the scarey scenes of a horror movie) and not fully replace or confuse them with elements that work for other genres (e.g., slapstick). Similarly, the software designer must be attentive to the connections between the interactive elements upon which she relies and those elements which are appealing to a child.

The research reported in this paper represents an attempt to establish the validity of the above position prior to the development of verification oriented research. We think this is necessary as our conceptual approach is somewhat different than prior research in this area. Previous attempts to schematize or categorize software have often been done according to adult conceptualizations (e.g., Jonassen, 1985; Taylor, 1980). According to our hypothesis, it is the *child's* perception and categorization of programs, particularly the interactive aspects, which determine how we should think about designing software (c.f. Shapiro, 1987; Winograd & Flores, 1986; Turkle, 1984). Accordingly, our first research question is whether interactive formats have a strong enough influence on how children categorize software so that we may speak of *genres of interactivity*. A second way our research differs from previous approaches is that some of the best works on the motivational aspects of computer software have tended to ignore differences across software. For example, Malone (1981) writes of the role of challenge in creating motivation. Challenge, however, is not what motivates us to use a particular word processing program. Rather we choose those programs which conform to our needs as writers.* We intend to show that the motivating elements of software vary from program to program and are dependent to a large degree on the interactive premise of the software.

To begin exploring the relationship of interactive software and motivation we collected three sets of data:

1) By having fifth graders sort software titles into piles of "like" programs, we investigated how children categorize educational software.

2) We gathered information about the motivational power of programs by asking the students to indicate on a scale of one to three how much they like to use each program.

3) Through group interviews we identify the interactive elements of the favored software genre - adventures.

All of the studies were conducted with fifth graders enrolled at Royale Elementary School in Darien, Connecticut. The Darien School District has an ample computer program which is laboratory based. Children use the computer lab during free time and regularly as part of class time. The software selection and usage is closely linked with the curriculum. There are enough computers for children to work individually if they choose. And, a full 75% of the children had computers (or video games) in their household. We comment where we feel that this usage profile may impact the generality of our findings.

Genres of interactivity

If children think of software in terms of interactive format, then it is reasonable to expect them to use similarities in interactive format across programs as a basis for categorization (cf. Chi, Feltovich & Glaser, 1981). To decide if a cluster of programs coheres by interactive equivalences, without a crisp definition of interactivity, could be problematic.[*] However, we expected that this problem of identification would not be too great. It was our prediction that students would create and label a few categories which unquestionably suggested interactivity.

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* In fairness, Malone (Malone & Lepper, 1984) later added an interpersonal dimension of motivational variables which capture the interactive appeal of a larger array of software.

Fourteen chilren (balanced for gender) each received a stack of 56 index cards which had an educational software title typed on one side. Children were directed to "sort the cards into piles of programs that are alike." No further instructions were given. Students were left to interpret "alike" and decide how many piles to create. The groupings were recorded and children were asked to label each pile.

A separate manipulation removed programs which a child had not actually used. We only consider the 26 programs that were known by at least half of the students in both the sorting task and the motivational ranking task below. The sortings were subjected to a cluster analysis using the Rao-Russel coefficient of similarity and a complete linkage approach. The label or labels which occur most frequently over all the programs within a cluster are used as names for the resulting cluster.

The analysis yielded seven clusters of programs which could be differentiated according to the labels assigned by the students. We give the label and our interpretation of the cluster along with the programs which were included. The order of the programs and clusters listed below replicates the ordinal positions within the final clustering. For example, *Bank Street Writer* is most closely linked to *LogoWriter* and most distant from *Path Tactics*.

Writing or Language Arts

These programs are typically seen as used for writing or typing practice.
Bank Street Writer, LogoWriter, Paws, Writer Rabbit.

Print-out Programs

This category is defined by the program's emphasis on the goal of printing something out.
Print Shop, Print Shop Companion, Time Liner.

Puzzles

One student called this type of program "mind puzzles." This category revolves around deductive style reasoning.
Gertrude's Puzzles, Puzzles & Posters.

States or Social Studies

These programs all involve learning about the 50 states. However, the titles alone may define the category.
Dataquest: The Fifty States, Game of the States, States and Traits, Coast to Coast.

Adventure/Journey/Mystery

The anchoring attribute of this category appears to be computer simulation of the physical world. One student made the astute distinction between mystery and adventure as one of solving vs. looking. These two types of programs are strong sub-clusters within this category.
Odell Lake, Oregon Trails, Goodell Diamond, Treasure Hunter.

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[*] We take interactivity to mean something broader than and prior to a simple distinction between computer and "passive" media. As such, interactivity is a potentially unbounded concept ranging in examples from playing a game of tennis to reflecting on one's own thoughts. In attempting to define interactivity, one could easily flounder in debates over false problems: Can true interactivity only take place between two humans? Is drill and practice less or more interactive than inquiry-based software? Fortunately, our ultimate goal as researchers is not to come up with a necessary and sufficient definition of interactivity. Indeed, if there are concepts which are meaningful through the family resemblances of their examples, interactivity surely must be one. Rather, our goal is to organize discourse about those shared and differing attributes which characterize the many situations we call interactive.

Putting things together

Students have to construct something and test it.
Clock Works, Woodcar Rally.

Math

This category includes many of the programs that deal explicitly with number. Within this cluster there is a tendency for drill and practice programs to be associated with one and another.
Multiplication Puzzles, Subtraction Puzzles, Math Blaster, Circus Math, Quotient Quest, The Market Place, Path Tactics.

There are two strong dimensions used to develop the categorizations: content area and interactive model. The three content area clusters, language arts, social studies, and mathematics should not be very surprising. Given schools' strong partitioning of knowledge into curricular domains, one would expect children to bring their categorization of school experience to their categorization of software. This effect is probably heightened by Darien's use of the computer lab within class periods.

Of greater interest for our purposes are the other four groupings, especially the printer, adventure, and building programs. From this small sample of children and programs, it can be seen that children are quite attentive to interactivity in their conceptualization of software. Each of these represents an identifiable way of interacting in and with the world: using tools, navigating, searching, and creating. One might easily imagine that less interactive but more frequently tauted aspects of software, such as graphics quality or engagingness, could have been used to equate the software. Interactive models are not limited to action in the phsyical world, although this is the currently favored genre of fifth graders. There also appears to be a sub-cluster within the math grouping in which the student competes with an animated agent within the computer thus modeling interpresonal interactivity. Undoubtedly, there are many other models of interactivity upon which computer programs do or will rely.

Motivation and types of software

If programs are equally motivating but rely on different models of interactivity, it is likely that the motivation originates from different sources. To investigate the relationship of motivation to interactive formats, we operationalized the motivational strength of a program to mean how often a child likes to use the program. 22 fifth graders (balanced for gender) completed a questionnaire indicating how often (always, sometimes, never, unknown) they would choose to use each of the 56 programs in their free time. Below is the ranking, from most motivating to least, of those programs that were known by at least half of the students. A score of three would represent the most motivating program.

(2.50)	Oregon Trail
(2.50)	Print Shop
(2.45)	Odell Lake
(2.32)	Bank Street Writer
(2.21)	Print Shop Companion
(2.11)	Wood Car Rally
(2.10)	Goodell Diamond
(2.09)	LogoWriter
(1.95)	The Market Place
(1.94)	Path Tactics
(1.94)	Quotient Quest
(1.92)	Dataquest: The Fifty States
(1.92)	Puzzles and Posters
(1.83)	Coast to Coast
(1.82)	Multiplication Puzzles
(1.81)	Time Liner
(1.80)	Gertrude's Puzzles
(1.79)	Game of the States
(1.72)	Clock Works
(1.69)	States and Traits
(1.68)	Paws
(1.65)	Circus Math
(1.58)	Treasure Hunter
(1.55)	Math Blaster
(1.46)	Writer Rabbit

Attitudes towards software programs appear to be fairly well defined across the population as there is a highly significant effect for program type (F = 6.9). There is a significant effect on motivation when clusters are treated as groups within an anova (F = 7.75). Adventures and the programs which generated printer output were significantly prefered to the other clusters (Scheffe test at $p < .05$) but not to one and another. We will discuss the source of this preference in the next section. Interestingly, there is an interaction between gender and program type (F = 1.7, $p < .03$) but not between gender and cluster type (F = 1.45, $p > .22$). This suggests that it is not math or writing per se to which girls and boys object, but rather specific, and perhaps prototypical, implementations of the category of software. However, the sample is too small to be confident in a failure to find effects or to begin parceling out interaction effects.

Oregon Trail and Print Shop are representative programs from the highly motivated clusters of adventure and print-out. These two programs are extremely different in the sorts of interactions, goals, and sources of satisfactions a student can expect. Although one might wish to claim that the same sorts of design elements make each motivating (e.g., an appropriate level of complexity or challenge), this seems to be the wrong level of analysis. We suggest that what makes each program so successful is the fit between the reasons the child wants to use the program and the interactive environment it creates. A program which includes navigational goals should create a spatial environment. Being able to jump from menu to menu in Oregon Trail (as is the case in Print Shop) would destroy the interactive premise of travel. It would undermine our expectations of interactions within a spatial environment. The program would loose much of the motivational power it gains by relying on our enjoyment and knowledge of navigating in the world.

The source of interactive expectations.

If a child perceives a program as an adventure game, she prefers to see a first-person surrogate carry out her actions within the program's environment.* On the other hand, in a math, drill and practice setting, no such surrogate is expected (perhaps to move numbers around on the screen), nor does it seem to provide motivational enhancement beyond the temporary effects of novelty. Why might this be the case? In simplest fashion, much of what is enjoyable in software borrows from what is recognized as an enjoyable activity in the real world. Children have a prior model of interaction which includes surrogates (e.g., dolls) for fantasies. On the other hand, the activity and feedback involved with worksheets - animated or not - have never included the notion of a surrogate. There would be a mismatch between their expectations of the worksheet genre of interactivity and its delivery with fantasy elements.

Our central tenet is that children's motivation towards educational software can be understood to a large extent through the specifiable expectations children bring to the different genres of software. These genres of software are created and identified on the basis of the interactive models which rest upon the child's experiences in the world. We maintain this position because children bring previous real-world interactive experiences to their understanding of the various formats of educational software. It is easy to see how they analogize or equate software to various real-world activities. (E.g., This program is like going on a trip; this one is like taking a test; this one helps me make something.) They must import the goals of interactions in the world to find satisfaction within software. Software does not create goals and lasting motivation out of a vacuum - the computer is not *that* inherently motivating. Rather, a piece of software will borrow the motivating goal structure and the attendent interactive environment which supports a particular type of interaction in the world. The two most highly motivating clusters of programs, adventures and printing software are notable in their close linkage with the world. One facilitates interaction within a simulated physical world, the other assists social interaction through the creation of signs and cards. They each borrow their appeal through their different connections to real world interactions. Further, they each appear to be the most successful within their genre of software because they maintain fidelity to the previously experienced goals and environment of their interactive premise.

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*This was revealed through the group discussions discussed in the next section.

What might an interactive genre look like?

If children are given an opportunity to create a program, they will create one which is consistent with, and motivating because of, the interactive genre which serves as its premise. To explore whether students would emphasize a coherent set of interactive elements and what those might be, the two authors conducted group interviews with two different sets of five children. The question which anchored the discussion was, "If you were to make a computer program, what would it be like and what sorts of things would you include?"

The responses of both groups were strikingly similar in their preference for adventure games. Each group distinguished these from mysteries and puzzles. These results are in accordance with the distinctions uncovered by the clustering task and the motivational rankings. By looking at the different suggestions the students made, we get a better sense of the coherence of the interactive model and collect evidence for an extensive definition of the adventure genre of interactivity.

The children stated that they wanted an impactable environment. We might call this a *causally coherent* model of interactivity in which consequences must reveal themselves through changes in the environment. All actions, student and computer, must be similarly constrained by the environment. Decisions that are made within the program should change the environment in a causal fashion. The legacy of these changes remain in play throughout the course of the interaction. For example, forgetting to plant the corn will become a damning mistake only when the food stores run out. Students pointed out several times that they did not want the program to give disengaged, omniscient, or external feedback; all consequences and computer reactions should be a natural result of the causal environment the program creates.

A second interactive model prefered for the adventure game is a spatio-temporal model. For example, they liked an ability to move in any direction spatially. This can be contrasted with programs in which the child always moves forward. However, complete freedom of movement and choice is not a superordinate principle of interactive design. The children explicitly stated that they did not like the capability of going back in time to correct a mistake. Ideally, an adventure environment will replicate the advantages and constraints of a spatio-temporal world.

Students repeatedly stated that they liked to explore and learn from their options and mistakes. They liked having to discover the sub-goals and emergent goals that must be satisfied to achieve the larger goal of the adventure. They wanted the program to be somewhat unpredictable but in a fashion consistent with the laws which govern the program's environment. They wanted optional levels of difficulty and novelty. In other words, they wanted to learn through interactions within a rich causal environment.

The adventure game relies on three basic interactive models which are derived from the child's interactions with the physical world: causality, spatio-temporality, and exploration.[*] The discovery or immersion learning style they have chosen finds a natural model within their own lives (Papert, 1980). However, it is important to note that this is only one genre of interactivity and a style of learning which grows from it. It is important to imagine what sorts of social interactivity and learning styles will become supportable as computer power becomes more available in the classroom.

Directions and conclusion

The methods of enhancing motivation within different interactive settings will differ depending on the goals the user generally attributes to certain types of interaction. Although the goal is ultimately to learn something, the use of interactivity can bring a much larger set of goals and expectations to bear. It is central to any interactive design that these expectations are played upon. As a first step in delineating the nature of these expectations, it is worthwhile to think of the different types of interactions a user might expect within a given genre of interactivity. A practical way for a designer to follow this prescription is to ask herself what sort of interaction does this computer instruction seem most like and what sort of role does the computer play in the interaction (e.g., partner, adversary, game board, world, referee, reference tool, museum, etc.). Subsequently, the designer can consider what things make this sort of interaction most satisfying and work onward.

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[*] There were other elements of adventure games which the children mentioned such as codes, fantasy, and being able to choose the characteristics of their surrogates. There were also things which the children claimed were unimportant: graphics, high action, points, winning, and, sound. It is worth noting that some of the things excluded are precisely those things which are mandatory for the success of other genres of interactivity. It would have been interesting to have asked the students to design the ideal drill and practice program as a source of contrast.

The unique features of the new and highly plastic interactive technologies have not been fully explored, either theoretically or empirically. Designers currently rely on models of development which are often out-dated or prematurely reductionistic. Much of the literature on motivation in instructional technology attempts to include all designs within large matricies and continuums of factors. They do not take into account the qualitative differences of children's expectations in their encounters with instructional technologies. Much like film, there are genres of software (in use and developing) which capitalize on the child's motivations in fundamentally different ways. Our future research will attempt to prove the interrelation of interactive format and motivation through an experimental design. However, the next step is to continue the discourse with children about the different interactive elements and their groupings into genres. It is here that we will find the best ingredients for coherent and motivating design recipes.

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Title:

Instructional Development and Classroom Technology: Prototype Classrooms at the Navy's Surface Warfare Officers School

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Instructional Development and Classroom Technology: Prototype Classrooms at the Navy's Surface Warfare Officers School

In 1988, Iowa State University's College of Education and Media Resources Center (Ames, Iowa), contracted with Oak Ridge Associated Universities, Inc. (Oak Ridge, Tennessee) to develop a plan to promote the increased use of educational technology by the instructors and students of the United States Navy's Surface Warfare Officers School (Newport, Rhode Island). This paper is a description of the process used to develop, implement, and evaluate this plan which closely followed traditional instructional design procedures. First, a needs assessment was conducted. Second, a design plan was developed and critiqued, and third, prototype systems were installed and evaluated.

I. Needs Assessment

The needs assessment phase of this project had three components. First, it was necessary for program planners to gain an understanding of the organization of the Surface Warfare Officers School (SWOS). Second, the SWOS curriculum was evaluated to determine the applicability of different instructional technologies. Also, SWOS instructors' teaching styles, competencies, and preferences were identified. Third, SWOS facilities were analyzed so that recommendations could be made that were relevant to the classrooms and laboratories used by the SWOS instructors.

The Mission and Organization of the Surface Warfare Officers School

The Surface Warfare Officers School Command (SWOS) is located in Newport, RI. Its mission is to:

> Provide the Naval Surface Warfare Force, through a system of functional training, with officers professionally qualified to serve as effective naval leaders on surface warfare ships with the ultimate goal of Command-at-Sea.
>
> Serve as the focal point for development and integration of qualification standards and functional training in support of the established continuum of Surface Warfare Officer professional and billet specialty training.

The SWOS has five permanent buildings and five temporary buildings. These buildings serve as classrooms, as offices, and as laboratories. There are five schools at SWOS (figure 1):

1. The Division Officer Training School - This school prepares prospective Surface Warfare Officers for their first assignments by providing fundamental instruction in basic fleet training. This training emphasizes the knowledge and skills required to assume duties as a Division Officer, Officer of the Deck (in port), Combat Information Center Watch Officer, and Junior Officer of the Deck. Additionally, the course provides a foundation of knowledge in combat systems, propulsion engineering, and damage control.

2. The Department Head Training School - This school prepares mid-grade Surface Warfare Officers to confidently execute department head level duties aboard surface ships. Training addresses shipboard equipment in a systems fashion, stressing equipment interaction and interdependence. It also provides advanced training in managerial, operational, and technical areas needed to support an officer's assignments to a specific department in a given type of ship.

3. The Prospective Commanding Officer and Prospective Executive Officer (PCO/PXO) Training School - The PCO course's primary mission is to prepare line officers, eligible for Command-at-Sea, to properly execute that authority in surface ships. The training addresses the professional aspects of taking ships to sea and executing their battle functions as units in the tactical forces of the U.S. Navy. The school also addresses command responsibilities, ship tactics, techniques for evaluation and control of ships systems and equipment, current fleet policies and practices, and specialized information appropriate to the ship type to which students are ordered. The PXO curriculum is designed to provide the Executive Officer with an improved concept of supporting the Commanding Officer in controlling and evaluating the performance of the ship.

4. The Damage Control Training School - Courses in this school are to provide training in shipboard damage control procedures. In-depth study is provided in damage control administration and training, divisional administration, damage control equipment systems, and other damage control concepts.

5. The Engineering Specialty Training School - This school's courses of study prepare junior, division officer level, Surface Warfare Officers to execute their prospective Engineering Department Division Officer duties aboard surface ships. The training emphasizes technical and equipment details related to the respective propulsion plant systems and their operation. Instruction in the basic principles of electricity is emphasized. The training is developed toward an understanding of proper and safe propulsion plant operation.

The Curriculum and Instructor Analysis

In order to understand the media needs of SWOS instructors and curriculum, a process was followed that analyzed these needs. The goal of this process was to obtain as much information as possible about:

1. The current status of the instructional systems used at SWOS.

2. Instructors' expectations for media systems.

3. Curriculum activities that required media support.

4. Teaching procedures and styles requiring the use of media.

Information was obtained during two visits to SWOS. First, an initial visit was made to Newport and the Surface Warfare Officers School. The purpose of this visit was to familiarize the project director with SWOS, and to explain to SWOS officers the procedures to be followed by the Iowa State University (ISU) team. A short visit was made to each of the five schools of SWOS, and brief discussions concerning media systems were held. Many classrooms, offices, and laboratories were also visited.

Next, two members of the ISU team visited SWOS to complete an in-depth evaluation designed to determine what media equipment items were needed to support the curriculum and instructors of SWOS. This visit was organized to include five activities: in-depth discussions with SWOS officers and staff, a written SWOS instructor survey, an evaluation of the SWOS curriculum, class observations, and a solicitation of media equipment requests from the officers and staff of SWOS.

Additionally, a comprehensive facilities review was completed. This review included an examination of SWOS classrooms, offices, and laboratories. It also included an inspection of floor plans and room schematics.

DISCUSSIONS were held between the needs assessment team and selected SWOS officers. These discussions were of two types - general ones with central SWOS support staff, and more specific discussions with officers from each of the five SWOS schools. These discussions were organized to obtain as much information as possible abut the media needs of SWOS. The following conclusions were derived from these discussions:

1. Most teaching conducted at SWOS was teacher-centered. In other words, most instruction was "lecture with demonstrations". The teaching varied somewhat between the SWOS schools, but most classroom instruction was primarily lecture with teacher-led discussions.

2. Instructor background and experience with media equipment was varied. Some instructors were competent, some were inexperienced, and most were self-taught.

3. Instructors prepared their own teaching materials. Many stated that they would have liked to have been able to prepare more sophisticated teaching materials, assuming production techniques were easy to learn, and production equipment and facilities were readily available.

4. Instructors stated that they would like to have all classrooms equipped with a similar configuration of support equipment so teaching would not have to be modified depending on which classroom an instructor was assigned to.

5. Instructors felt the following four kinds of audio-visual equipment were necessary: overhead projectors, slide projectors, 16mm motion-picture projectors, and video displays. They also felt that computer display or projection was important.

6. Training in teaching was adequate, but training in the use of media was minimal. Most instructors had learned on their own, and expressed concern about the installation of overly complex classroom audio-visual equipment. They felt equipment should be durable, reliable, accessible, and easy to use.

7. Instructors requested equipment for video recording of class sessions for student review and for instructor self-evaluation.

The next component of the research visit was the INSTRUCTOR QUESTIONNAIRE. This seven-question survey was distributed to SWOS officers. Eighty-five questionnaires were returned (figures 2 & 3).

As part of this questionnaire, instructors were asked "open-ended" questions about the need for classroom equipment and media production facilities. A variety of responses were made. For example, several SWOS instructors mentioned that they would like to have the school's chalkboards replaced with dry-marker metal boards. Also mentioned was the need for "remote control" of projection equipment. Several instructors felt that computers should be placed in classrooms, and computer projection equipment should be available.

When asked about media production, 94% of the SWOS instructors who responded to the questionnaire felt that additional media production support was needed. Traditional graphics production was mentioned often, as was a need for video production equipment. The VHS format was considerably more popular than any of the other video formats. Transparency production was mentioned most often as a need that, if met, would have the most immediate impact on teaching.

The questionnaire results made it fairly obvious that SWOS instructors wanted improved classroom audio-visual systems, and that they felt additional media production was critical to their success as teachers. No negative comments about the need for improved audio-visual systems were given.

A CURRICULUM EVALUATION was also conducted during the research visit. A number of curriculum plans from each of the SWOS schools were reviewed. The results of this review supported many of the generalizations obtained during other phases of the visit. Specifically, the review of the curriculum generated these observations:

1. Instruction was based on goals and objectives, with student learning outcomes clearly stated.

2. Student guides were used throughout the SWOS curriculum. Often, students followed along in their guides during teaching.

3. Instruction was teacher-centered. Teachers lectured to present information, and discussed with students to clarify key points.

4. During classroom instruction, instructors often used materials produced directly from student guides. Specifically, charts, drawings, and graphs were copied from student guides and converted into transparencies or 2" x 2" slides.

CLASS OBSERVATIONS were used on several occasions to verify the conclusions derived from other portions of the research visit. Several generalizations were worthy of note:

1. All instructors observed were knowledgeable in the topic they were presenting and were skillful lecturers.

2. All instructors who were observed used instructional materials during their lectures. Transparencies were used most often, followed in frequency by real objects and slides.

3. Students seemed interested during the lectures and inquisitive during discussions. In almost all classrooms observed, students were using a number of handouts (charts, maps, drawings, study guides) during lectures. Desks and table tops were used by students to spread these materials in front of them so they could be easily referred to during lectures and discussions.

4. In a number of instances instructors were forced to use audio-visual equipment inappropriately. This was because screens were mounted incorrectly, pieces of projection equipment were place inappropriately, or lenses on projectors were not of the proper focal length. In most cases this was not the fault of the instructor, but was due to the configuration of the classroom or the limitations of the audio-visual equipment available to them.

5. Audio-visual equipment pieces were a critical component of instruction. Instructors used equipment and seemed desirous of making greater use of equipment.

REQUESTS for audio-visual equipment and support materials were supplied to the ISU team by SWOS officers and staff. These requests were in the form of lists of equipment and copies of brochures. These specific requests were merged with the more general information obtained during the other phases of the needs assessment visit. Most notable were the following requests:

1. Requests were made for media production equipment so instructors could easily and efficiently prepare instructional materials.

2. Requests were made for more video display/projection equipment in the VHS 1/2" cassette format.

3. Requests were made for computer display/projection equipment so computer output could be used during classroom presentations.

4. Requests were made for newer, easier to use, 16mm projectors.

5. Requests were made for computer software so instructors could prepare graphics materials for classroom use. Macintosh and "Macintosh look-alike" systems were requested most often.

The Facilities Analysis

A review of all current SWOS classrooms, support spaces, and simulation facilities was conducted using on-site visits and an examination of floor plans. Most classrooms and support spaces were observed during instructional use, as well as during non-usage time. The intent of this facilities review was to identify and categorize the basic types of instructional environments found at SWOS. Also, the review visit was to identify the physical and structural restrictions that influenced the placement of equipment. The results of the facilities analysis were organized into nine categories:

1. Physical layout (size, shape, and seating orientation)

The various SWOS classrooms were grouped into five basic physical layout patterns (four basic categories and a fifth category to cover one-of-a-kind facilities). The four basic patterns and the fifth miscellaneous grouping identified were (see figure 4):

> CATEGORY 1. A rectangular space with the front of the room oriented on the longest dimension. Generally, there were two entrances with windows on the opposite wall. The rooms seated approximately 45 at fixed desks/tables.
>
> CATEGORY 2. A nearly square format space with two fixed seating areas on either side of a structural column(s) located near the front of the room. One entrance was located at the rear of the space and windows were on one or both sides of the room. The rooms seated approximately 30-35 in small desks.
>
> CATEGORY 3. A square format with small dimensions (approximately 16' x 18') with one seating area. One entrance was located at the rear or front of the space with windows on one wall. The rooms seated approximately 10-15 at movable tables or desks.
>
> CATEGORY 4. A rectangular format space with standard classroom dimensions (approximately 30' x 40') with two seating areas and with the front of the room oriented on the narrow dimension. The rooms had one or two entrances with windows on one wall. The rooms seated approximately 30-35 at movable tables.
>
> CATEGORY 5. Miscellaneous formats, ranging from a large, three-bay auditorium to small simulation (6' x 8') training facilities. Included were a variety of sizes and shapes which varied dramatically from categories 1, 2, 3, or 4. Orientation and seating patterns also varied.

2. Lighting and lighting control

In general, the lighting in the SWOS instructional spaces was recessed fluorescent fixtures that were controlled in banks (two or three) by on/off switches near entrance doors. A few rooms had some fixtures or additional lights on dimmer controls. Most spaces with windows had hand operated darkening drapes for control of natural light.

3. Projection screens or surfaces

All SWOS classrooms had one to three screens located on keystone brackets. Many were mounted approximately 12-15" from the ceiling and oriented parallel to the chalkboards. The screen sizes varied from 70" to 96" and were generally of the matte surface type. Mounting location and front orientation varied from room to room.

The viewing angle and screen orientation of the SWOS classrooms varied greatly. Generally, the screens did not allow for the proper, optimum viewing of screen images by all students.

The ceiling height of SWOS classrooms varied from less than the normal 8' height to 14' high in specialized areas. Generally, the ceiling height was determined by ceiling tile of the T-bar suspended acoustic type.

All SWOS classrooms had chalkboard surfaces located at the front of the room. Many also had side-mounted boards. The type of boards varied from blank slate to green board surfaces, all of which utilized chalk materials. Tack or mounting boards were located in some of the classroom spaces.

4. Electrical power

Most SWOS classrooms had electrical outlets distributed on all wall surfaces at the normal level. Only a few spaces had additional floor outlets near the room fronts for overhead projector usage. None of the SWOS spaces had power outlets located in ceilings or at work counter levels.

5. Equipment controls and sound

None of the SWOS classrooms had front-to-rear wiring or conduits for projection equipment controls. A few spaces had "temporary" ceiling-hung slide projector remote control cables.

Sound amplification or enhancement existed in only a few of the larger SWOS facilities.

Many Division Officer School classrooms had been wired for distribution of television and video. These spaces had one or two small 15" monitor/receivers mounted in the front of the room.

6. Structural

Some SWOS classrooms had structural columns located within the viewing and seating areas. These structural members limited projection and instructional activities.

7. Audio-visual equipment

The audio-visual equipment inventory of SWOS was dated, a "mixed-bag" of makes and models, and limited to primarily front screen projection items. Many of the overhead projectors had "standard" angle lenses and did not allow for the projection of properly sized images in the existing classrooms with their limited front-of-the-room operating space. Video equipment was of various models and formats, also. Only one "green screen" video projector in a specialized computer laboratory was in use.

8. Local production support

Similar to the audio-visual equipment, the local graphics and other media production equipment was dated, of mixed varieties, and unconnected in approach. The capabilities and availability of production materials and equipment varied from school department to department and from office unit to office unit.

9. A summary of facilities limitations and characteristics observed during review and analysis indicated:

a. Varieties of physical layouts

Four basic classroom layouts existed and each (along with the miscellaneous layouts) required individual audio-visual plans.

b. Ceiling height

The limited vertical height in all SWOS classrooms was a restricting factor in designing for the overhead viewing of visual instructional materials. In most rooms only 48" or less was available for unobstructed viewing of overhead images. Two options existed in most spaces: (1) structural ceiling height changes and/or (2) design of a media system not dependent upon large overhead visual images. Some rooms/spaces needed larger, electrically operated, and ceiling recessed screens.

c. Structural

Some classrooms and specialized spaces had structural members or columns in their seating and viewing areas.

d. Orientation

Several of the SWOS classrooms had their front orientation on the longest dimension of the room.

e. Standardization

There was a lack of standardization in the type of equipment and processes available for using and producing audio-visual presentations at SWOS. Much of the existing equipment was out-dated and in need of replacement.

f. Lighting control

The arrangement of the lighting fixtures, controls, and window darkening was generally found to be adequate.

Some areas required slight modification of the light switching of the room(s). Additional switches and dimmer controls needed to be added for instructor convenience.

g. Audio

There was a general lack of equipment and systems to produce or playback audio in the SWOS classrooms. These needs included audio amplification of spoken or recorded sound, enhancement of the sound portion of videos and films, and the ability to record sound in the rooms.

Acoustically, the SWOS instructional spaces were adequately treated with drapes and acoustic ceiling tile to allow "normal" classroom sound recording and playback.

II. The Design Plan

A. The Design Considerations

Based on the data collected during the needs assessment phase of this project, the following concepts were identified and used to develop the design proposal:

The Prototype Concept - Prototype is defined as the first or primary type of anything. Prototypes are models or originals. A prototype classroom would be one equipped with audio-visual systems before other classrooms were similarly equipped. At the Surface Warfare Officers School there are dozens of classrooms. Before any single plan for equipping these classrooms with audio-visual equipment is implemented, it should be first tested as a prototype.

The design plan had two major purposes. First, it contained recommendations for how SWOS classrooms and production areas should be equipped. These recommendations were both general and specific, and were used as the basis for the installation of systems in all SWOS classrooms. An important second purpose of this plan was its recommendation for the installation of prototypes which were to be installed, demonstrated, and tested before other classrooms were similarly equipped. The results obtained from this prototype process were used to validate the general recommendations of the plan.

The 80% - 20% Concept - Very early in the planning process, it became apparent to all concerned that recommendations needed to satisfy the audio-visual needs for not only the present situation at SWOS, but also for the predictable future needs of SWOS. As a result of this realization, the "80% - 20% Concept" was formulated. Stated generally, this concept implied that 80% of the recommendations contained in the plan would be to meet the current requirements of the SWOS curriculum and faculty. Specifically, this meant that more efficient methods of, and equipment for, slide, film, video, and transparency projection would be recommended for installation.

It was also apparent that new and different kinds of instructional technology support for SWOS were needed so that the curriculum and the instructional strategies were not constrained by the limitations of the available media. Twenty percent of the support proposed by this plan was to meet predictable future needs. Examples of this kind of support were the availability of easy-to-use computer projection/display hardware, and access to video production equipment.

Audio-visual systems should not dictate teaching style or curriculum offerings. Conversely, a lack of systems should not limit the techniques used by a teacher, or the kinds of activities offered to students as part of the curriculum. The "80% - 20% Concept" was an attempt to strike a balance between current and future needs.

B. The Design Recommendations

Based upon the design needs identified during the needs assessment phase of the project, seven kinds of capabilities were identified as necessary. These needs are listed below:

-- Video display

- videocassette playback
- computer projection/display (composite, RGB, CGA, and EGA capability)

-- Front screen projection

- overhead transparency projection
- slide projection
- 16mm projection
- screen placement
- lighting requirements control

-- Audio reinforcement/supplemental

- reinforcement of the audio portion of video and films
- public address amplification/recording
- auxiliary audio playback

-- Video recording

- session recording
- instructor analysis
- "minor" production

-- Graphics support - local production

- transparency production
- computer graphics/simulation development
- slide production
- scanning of documents

-- Student support/study

- video playback and viewing
- printed material study
- micro-forms use

-- Instructor support

- instructor office use
- networking with other areas
- classroom presentation development

There were five plans written, one for each of the five categories of classrooms. The five presentation systems each allowed for the display of composite, EGA, RGB, and CGA video images from a variety of sources, the display of standard projected images, audio playback and/or amplification, and the potential for overhead and rear-of-room video recording. All the presentation systems utilized modular components, hard (fixed) wired remote controls, mobile projection carts/cabinets, a fixed control console, and proper screen placement for optimum viewing within the room layout limitations. Each category of rooms was designed to accept video recording cameras at two locations (overhead and rear-of-the-room) using a portable recording control console.

Media Production Centers - Instructional materials used in teaching are obtained in one of two ways - commercially prepared materials can be purchased, and materials can be produced by persons who will use them. Commercially prepared materials are usually of a high technical quality and are preferred by many educators, assuming that they are relevant to the needs of the curriculum. However, commercially prepared materials have several disadvantages associated with their use. First, they are expensive to produce and to purchase. Second, because developers of commercial teaching materials normally want to sell their materials to the largest possible number of users, they tend to produce general materials. This often means that the items may not be exactly "on target" for specific curriculum objectives. Last, commercial materials are often difficult to revise.

Many professional educators now believe that developing and using locally produced materials is the most effective and efficient way to mediate instruction. Optimally, instructors should have support staff available to assist them. These staff persons produce graphics materials, develop videos, and carry out all other clerical functions needed by the teaching staff. Unfortunately, most institutions do not have the financial resources to hire support staff. Instead, professional educators advocate the installation of a media center in all schools. This media center would be equipped with easy-to-use production equipment, but with few people. The regular teaching staff would use the media center to produce their own classroom materials, rather than to have others produce media for them.

A local media production center is a facility where instructors can easily design, produce, and revise a variety of instructional materials. A media production center should be equipped with easy-to-use equipment and materials that permit the instructor to quickly and professionally develop high quality teaching media. Production centers should be located as close to instructors as possible, and the more often a technique is used, the more convenient it should be.

Two kinds of media production centers were needed at SWOS. One large, centrally located center was needed to provide the majority of support to most instructors. A second, satellite media center was needed at the Division Officers School.

1. The Satellite Media Production Center (SMPC)

The first media production center at SWOS was a prototype satellite center located in the Division Officers School. This center had the following types of production capabilities:

a. Manual and mechanical production of graphic materials

b. Computer production of graphic materials

c. Simple photographic production

d. One-camera video production and editing

Additionally, the SMPC needed equipment so that instructors could preview instructional materials that had been produced or for reviewing commercial materials.

2. Central Media Production Center (CMPC)

The primary media production center, located centrally, had the same capabilities as the SMPC. Additionally, it had the following capabilities.

a. Film to video transfer

b. Copy machine with enlarging and reducing capabilities

c. Computer-based instructional material production using various computer operating systems

d. Video format dubbing

C. The Design Plan Evaluation

The design plan evaluation was submitted to SWOS instructors for their review. A formal presentation was given, and the specific recommendations for prototype installations were made. After the presentation, questionnaires were distributed to obtain opinions about the proposal. Part 1 of the questionnaire asked questions about the proposed classroom installations. Part 2 contained questions about the prototype media centers.

Results (see tables 1, 2, & 3) indicated that the evaluators thought the plan for the classrooms was compatible with SWOS needs, had appropriate centralized control of equipment, and met expectations. The level of sophistication of the system was considered "about right". The evaluators were slightly less positive about the proposed media centers. However, ratings were generally very favorable.

III. Prototype Installations

Because evaluations were so positive, few modifications to the proposed plan were made. Only minor alterations to the recommendations, such as the placement of equipment in the classroom media control system, were made.

Six prototype systems were completed. One of each of the first four categories of classrooms had equipment installed in them. Also, the prototype satellite and central media centers were equipped.

A. Category 1 Classroom (figures 5 & 6)

The prototype classroom system design for category #1 classrooms incorporated the general design functions as follows (see figures 7 - 11):

1. Displaying video images using a ceiling mounted multi-scan projector, supplemented by the use of two, front-corner-of-room mounted video monitors.

2. Displaying film, slide, and overhead transparency images using a rear-of-room mobile projection cart and front-of-room instructor workstation.

3. Providing for audio reinforcement using a supplemental public address amplifier/mixer, sound input panel and player, auxiliary wall speakers, and the video monitor's built-in sound systems.

4. Allowing for video display and recording using a two-camera recording system (overhead and rear-of-the-room locations) with an instructor controlled console. The system (cameras and console) was designed to be partially mobile. The camera mounts and wiring were fixed in each classroom space, but the cameras and control console were a portable unit that could be moved from classroom to classroom.

5. Providing for instructor control and operation of all audio-visual equipment using a three part (audio, video playback, and video recording) console system. All power, lighting, and equipment controls were built into the console and wired permanently to the A-V items or patch boxes at the equipment sites.

6. Providing three screens , properly mounted and angled, to allow viewing by as many students as possible.

B. Category 2 Classroom (see figure 12)

The presentation system plan for category #2 classrooms incorporated the general design functions as follows:

1. Displaying video images using three video monitors (two front-corner mounted and one mounted on the center structural column).

2. Displaying film, slide, and overhead transparency images using equipment mounted in a cabinet on the center structural column, and a cart-mounted overhead projector.

3. Providing for audio reinforcement by using a public address amplifier/mixer, sound input panel, audio player, auxiliary wall speakers, and the video monitor's sound system.

4. Allowing video display and recording by using a two-camera recording system (overhead and rear-of-the-room locations) with an instructor controlled console. The system (cameras and console) was designed to be mobile with the camera mounts and wiring fixed in each classroom space and the cameras and control console a portable unit that could be moved from classroom to classroom.

5. Providing for instructor control and operation of all audio-visual equipment by the use of a three part (audio, video playback, and video recording) console. All power, lighting, and individual equipment controls were built into the console and wired permanently to the individual A-V items or patch boxes.

6. Providing two screen surfaces, properly mounted and angled, to allow efficient viewing by as many students as possible.

C. Category 3 Classroom (see figures 13 & 14)

The prototype presentation system plan for the category #3 classrooms incorporated the general design functions as follows:

1. Displaying video images (composite - EGA) using a front-corner mounted video monitor.

2. Displaying film, slide, and overhead transparency images using a rear-of-room mobile projection cart and front instructor workstation.

3. Providing limited audio reinforcement and playback using a sound input panel, audio player, and the video monitor's sound system.

4. Allowing for video display and recording by using a two-camera recording system (overhead and rear-of-the-room locations) with an instructor controlled console. The system (cameras and console) was designed to be mobile with the camera mounts and wiring fixed, and the cameras and control console as a portable unit.

5. Providing for instructor control and operation of all audio-visual equipment by using a three part (audio, video playback, and video recording) console. All power, lighting, and individual equipment controls were built into the console and wired permanently to the individual A-V items or patch boxes.

6. Providing two screen surfaces, properly mounted and angled, to allow viewing by as many students as possible within the limits of the physical environment.

D. Category 4 Classroom (see figure 15)

1. Displaying video images using two, front-corner mounted, video monitors.

2. Displaying film, slide, and overhead transparency images by using a rear-of-room mobile projection cart and front-of-room instructor workstation.

3. Providing for audio reinforcement by the use of a public address amplifier/mixer, sound input panel, audio player, auxiliary column wall speakers, and by using the video monitor's sound system.

4. Allowing video display and recording by using a two camera recording system (overhead and rear-of-room locations) with an instructor controlled console located in the front of the classroom. The system (cameras and console) was designed to be mobile with the camera mounts and wiring fixed and the cameras and control console a portable unit that could be moved from classroom to classroom.

5. Providing for instructor control and operation of all audio-visual equipment by using a three part (audio, video playback, and video recording) console. All power, lighting, and individual equipment controls were built into the console and wired permanently to the individual A-V items or patch boxes.

6. Providing two screen surfaces, properly mounted and angled, to allow efficient viewing by as many students as possible.

E. Satellite Media Production Center (SMPC; see figure 16)

One concern expressed numerous times by the officers and staff of SWOS was the need for convenient, easy-to-use, media production centers where they could prepare professional appearing instructional materials. In order to meet the needs expressed by SWOS officers for media support, two prototype media production centers were installed, demonstrated, and evaluated.

The SMPC had materials production and preview capabilities. Production capabilities included those for graphic, computer, photographic and video development. Equipment items for previewing media were also installed.

1. Production Capabilities - Production of graphic materials required the installation of the following types of equipment:

a. Mechanical lettering machine
b. Layout table
c. Thermal transparency maker
d. Slide previewing and tracing light table
e. Laminator

The following computer equipment was included in the SMPC:

a. A computer with "user-friendly" software
b. A scanner for digitizing printed materials such as charts and line drawings
c. A laser printer

The following photographic equipment was placed in the SMPC:

a. Single lens reflex camera
b. Copy stand (for making slides from flat pictures)

The following video equipment was placed in the SMPC:

a. Portable VHS video recorder with camera
b. VHS 1/2" videocassette editing system

2. Preview Capabilities:

a. A carousel slide projector
b. Overhead projector
c. A VHS 1/2" videocassette player with TV

F. SWOS Central Media Production Center (CMPC; see figure 17)

This center was the primary media production center for SWOS.

Capabilities - The CMPC had five categories of capabilities. First, it was a media production center for SWOS instructors. It had the same capabilities as the Satellite Media Production Center. Second, it contained one-of-a-kind media production items that were needed but not routinely used. For example, video equipment in the non-domestic PAL and SECAM formats were kept in the CMPC. Third, "back-up" equipment was kept here. Fourth, the CMPC was where software and supplies needed by SWOS instructors was stored. Last, the CMPC contained a study area for SWOS students.

G. Prototype Evaluation

Installation of the six prototypes was completed by Iowa State University staff during three visits to SWOS. When all systems were fully operational, a formal presentation of the systems' capabilities was made to SWOS commanding officers. At the conclusion of this presentation, the evaluation of the newly installed prototypes began. Officers were given a questionnaire to complete after they had a chance to use one or more of the prototypes. These questionnaires were collected several weeks later. Generally, results were favorable (see table 3). Suggestions for improving the prototypes included:

1. Relocate equipment controls in the console so they were easier to use.

2. Use of wireless microphones was not a good idea; use a microphone with a cable or do not use at all.

3. Install 5 1/4" disk drives in the prototype system's microcomputers. 3 1/2" disks were not installed in any of the command's other computers.

4. Put a dot matrix printer in the media centers.

5. Add a spotlight in classrooms to illuminate overhead camera work.

Generally, the evaluation indicated that SWOS officers were satisfied with the process followed and the equipment installed during this project.

Summary

Instructional design (ID) procedures were followed during this project. Traditionalists normally limit the application of the ID process to the development of instructional materials, or instructional sequences. This project applied ID procedures to the problem of providing appropriate hardware support for the five schools of the Navy's Surface Warfare Officers School. It was found that the design prescriptions of ID theory were just as appropriate for a hardware-based project as they were for software development.

Figure 1

Surface Warfare Officers School Command Organization

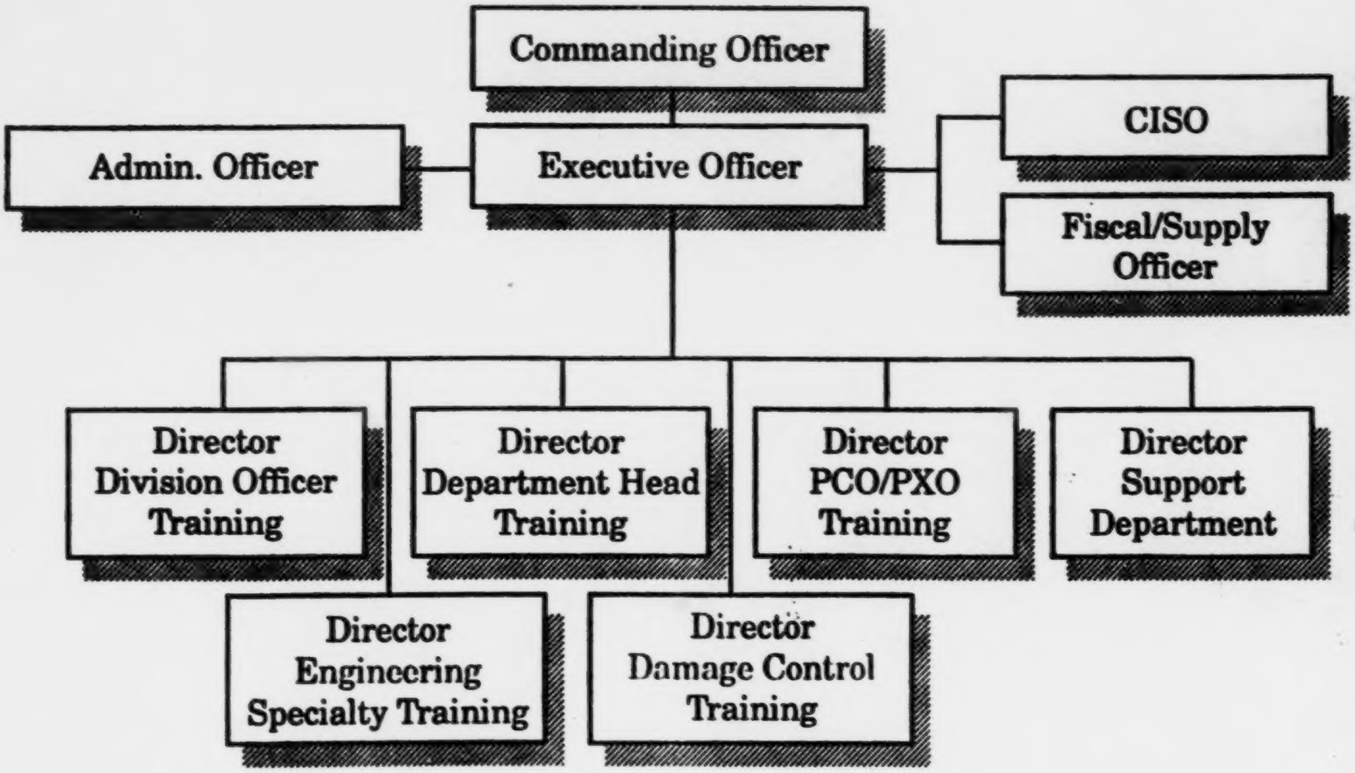
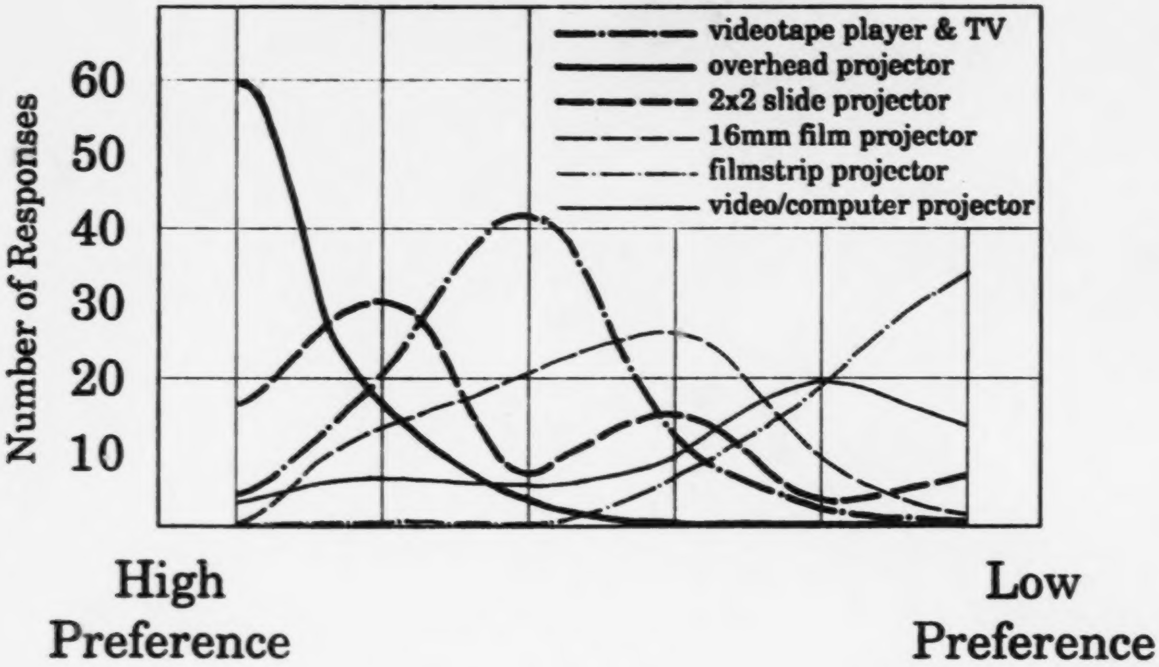

Commanding Officer
Admin. Officer
Executive Officer
CISO
Fiscal/Supply Officer
Director Division Officer Training
Director Department Head Training
Director PCO/PXO Training
Director Support Department
Director Engineering Specialty Training
Director Damage Control Training

Figure 2

Instructor Preferences for Teaching Equipment

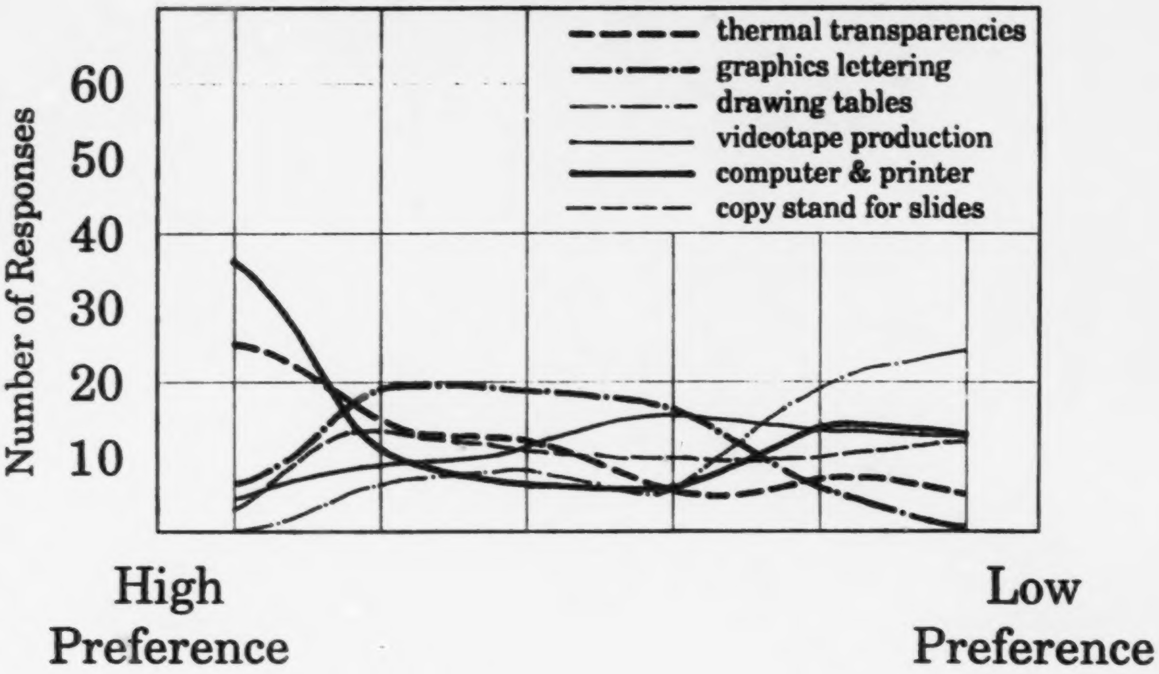


Rank Order of Most Important Teaching Equipment

	Rank					
	1	2	3	4	5	6
videotape player & TV	4	20	42	12	3	0
overhead projector	60	17	4	1	1	0
2x2 slide projector	16	30	7	15	3	6
16mm film projector	0	14	20	26	14	2
filmstrip projector	0	1	0	7	19	34
video/computer projector	3	7	6	9	20	14

Figure 3

Instructor Preferences for Media Production Equipment

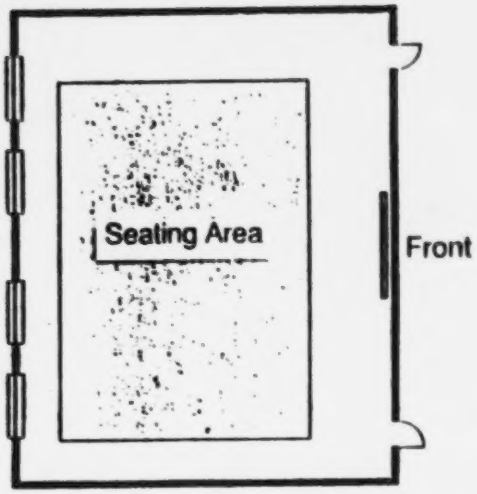


Rank Order of Most Important Media Production Equipment

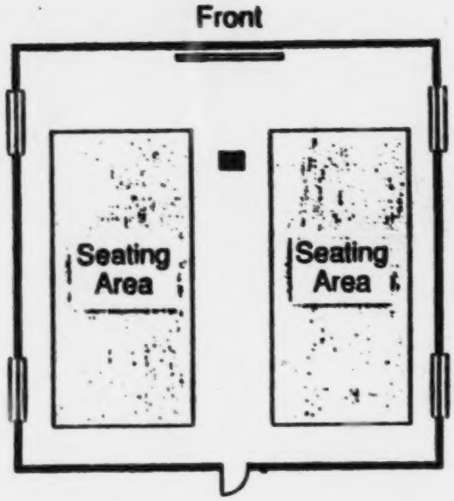
	Rank 1	2	3	4	5	6
thermal transparency production	25	15	12	5	7	5
graphics lettering machine	6	19	19	18	6	1
drawing tables	0	6	8	5	19	24
videotape production equipment	4	9	11	16	14	13
computer and printer with graphics	36	11	7	6	14	13
copy stand (single lens reflex for copying pictures onto slides)	3	14	11	10	10	12

Figure 4

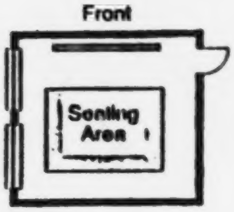
CATEGORY 1


Seating Area
Front

CATEGORY 2


Front
Seating Area
Seating Area

CATEGORY 3


Front
Seating Area

CATEGORY 4

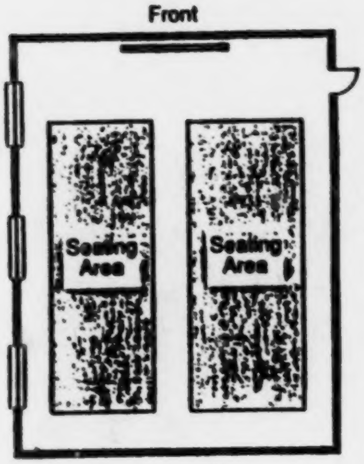
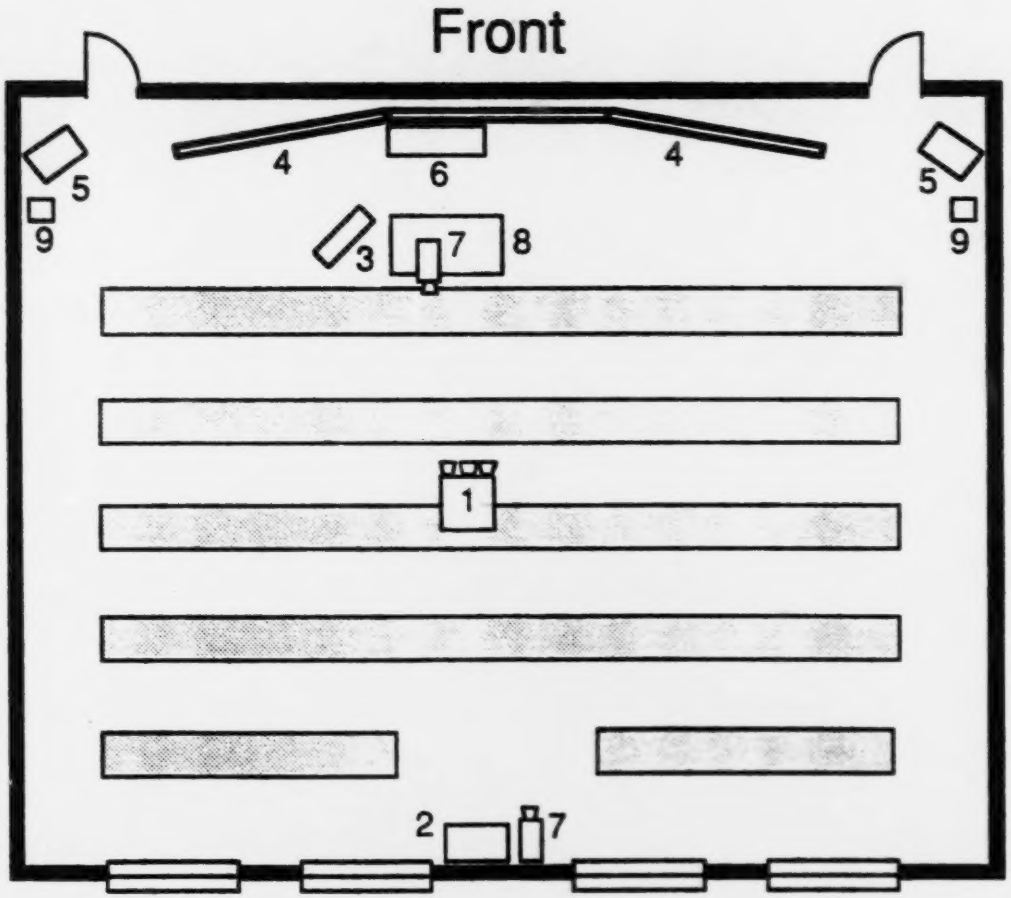

Front
Seating Area
Seating Area

Figure 5

Category #1: Classroom



1. Video Projector
2. Slide/film Projection Console
3. Overhead Projection
4. Screens, 8' & 70"
5. Video Receiver/monitor
6. Control Console, 19":
    - sound/PA
    - slide/film remote
    - video proj. remote
    - video camera controls
    - VCR
    - computer
7. Video Camera Locations
8. Instructor Work Station
9. Audio Speakers

Figure 6

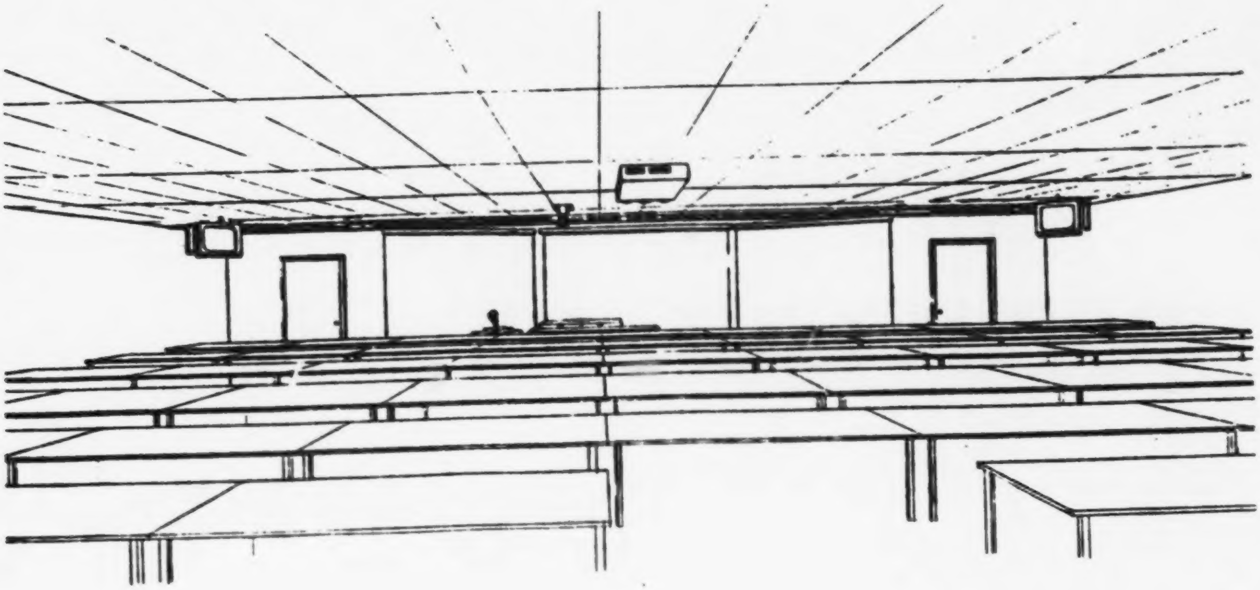
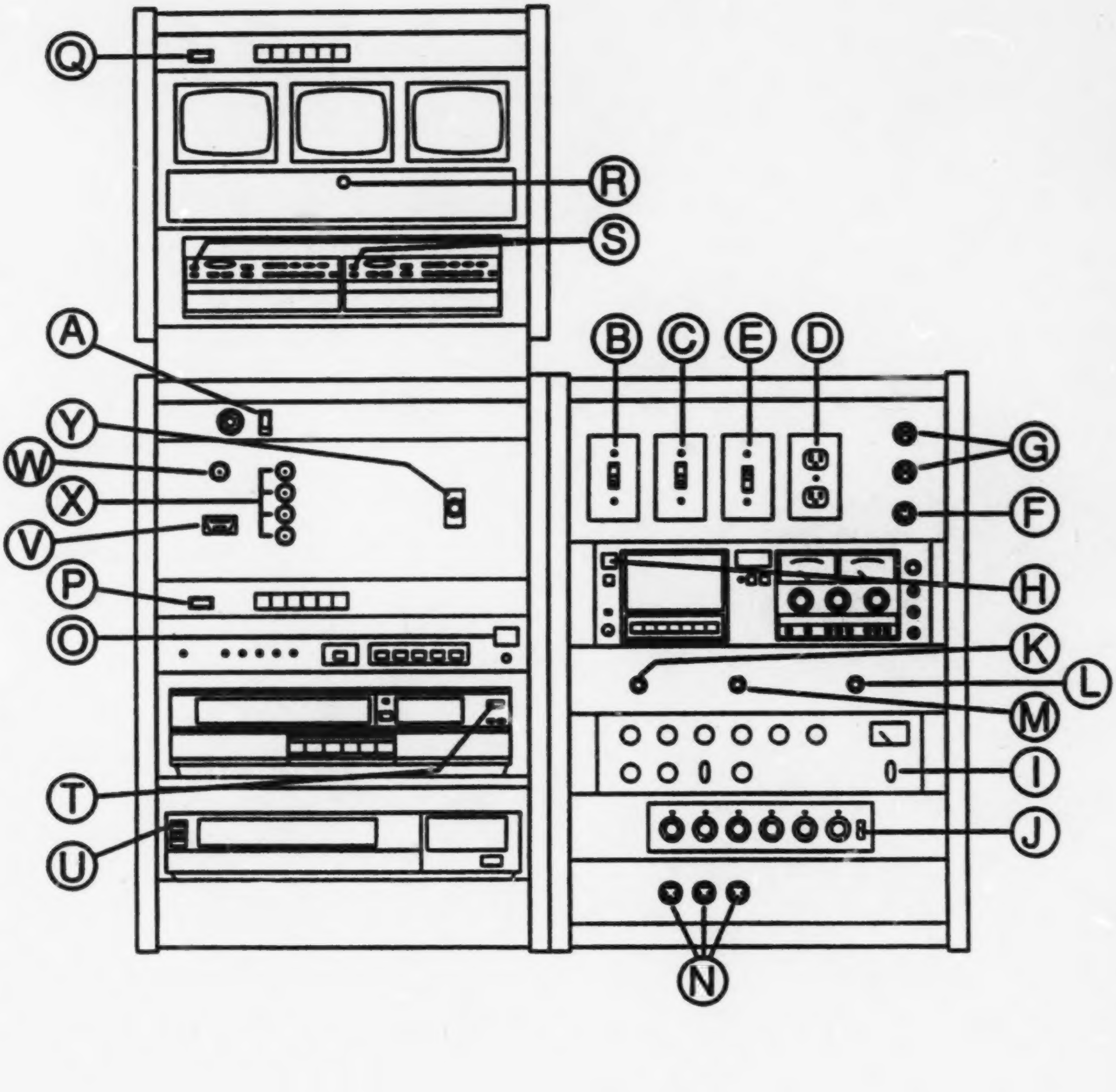


Figure 7

2.1 INSTRUCTOR CONSOLE - COMPONENTS


Q
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K
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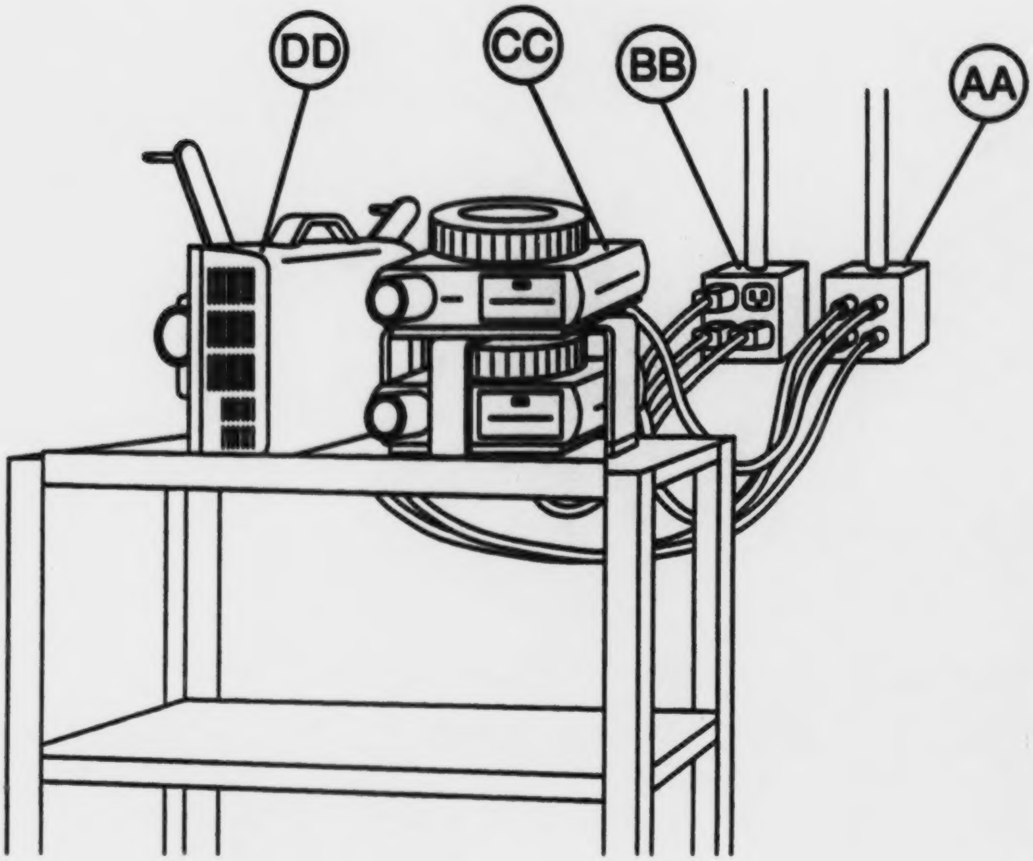
M
I
J
N

Figure 8

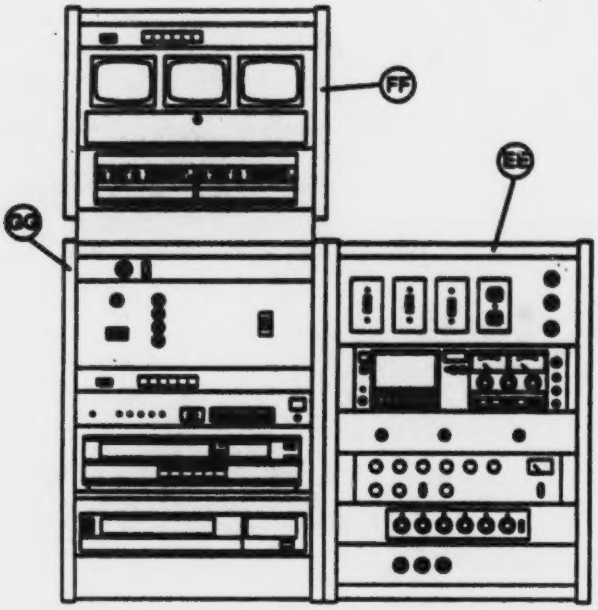
2.2 CLASSROOM DISPLAY/PROJECTION - COMPONENTS

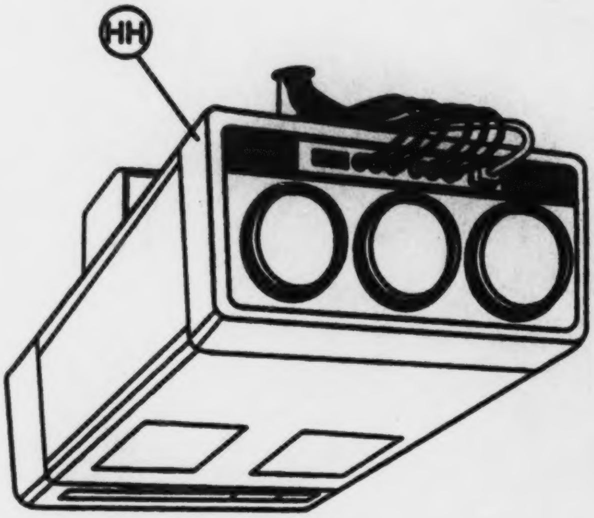


AA - Projector(s) remote control/audio inputs
BB - AC switched power - To switch (B) on front console
CC - Slide projectors
DD - 16 mm projector

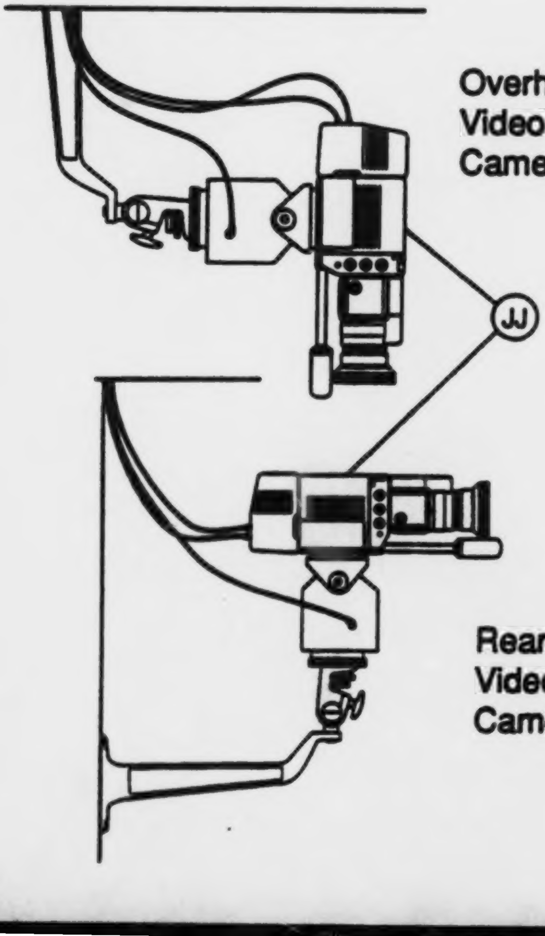
Figure 9

2.3 CLASSROOM VIDEO DISPLAY AND RECORDING - COMPONENTS



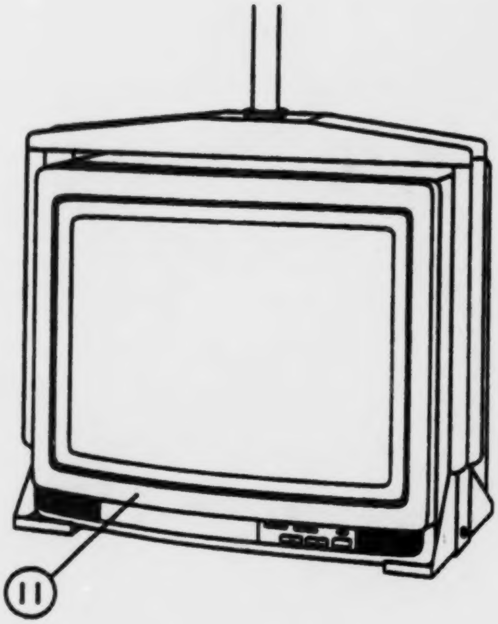


Video Projector



Overhead Video Camera

Rear Video Camera



Video Monitor

Figure 10

2.4 COMPUTER INPUT/DISPLAY - COMPONENTS

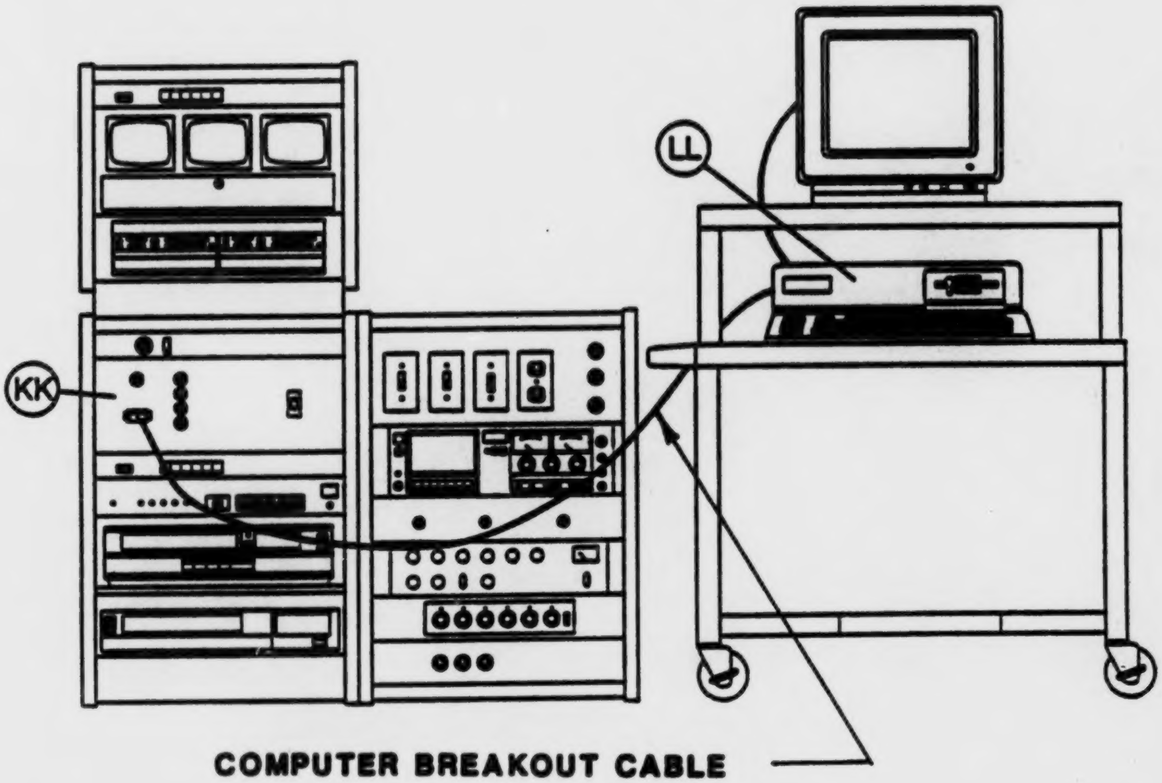

LL
KK
COMPUTER BREAKOUT CABLE

Figure 11

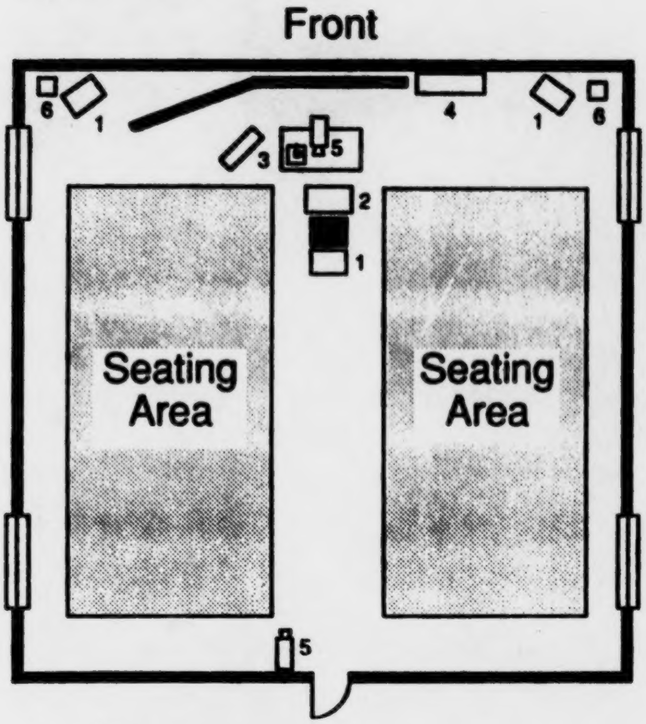
COMPONENTS IDENTIFICATION - SWOS CLASSROOM AUDIO-VISUAL SYSTEM

CODE	GENERAL FUNCTION	COMPONENT	MAKE & MODEL
Ⓐ	Master AC power control	AC power panel	Winsted 98700
Ⓑ	Switches AC power	Rear Proj. Console AC switch	---
Ⓒ	Switches AC power	Video Monitor(s) AC switch	---
Ⓓ	Auxiliary AC power	AC power outlets	---
Ⓔ	Raise/lower screen	Electric proj. screen control	Da-Lite Cosmopolitan
Ⓕ	Remote control input	16mm remote jack	Eiki
Ⓖ	Remote control input	Slide proj. remote jacks	Kodak
Ⓗ	Audio playback/recording	Audio Cassette Deck	Tascam 112
Ⓘ	Audio amplification controls	Mixer/Amplifier	TOA A903-A
Ⓙ	Microphones level controls	Microphone Mixer	Shure M68A
Ⓚ	Aux. audio input - line level	1/4 std. jack (audio panel)	---
Ⓛ	Audio output - line level	1/4 std. jack (audio panel)	---
Ⓜ	Audio input - 8 ohm level	1/4 std. jack (audio panel)	---
Ⓝ	Microphone inputs	Microphone jack panel	---
Ⓞ	Video projector controls	Video Proj. Remote Panel	GE Imager 300
Ⓟ	Select video display source	Video Switcher #2	Panasonic WJ-220/WJ-225R
Ⓠ	Select video recording source	Video Switcher #1	Panasonic WJ-220R
Ⓡ	View video source outputs	3-gang Monitor	Panasonic WV-5203B
Ⓢ	Video camera controls	Video Camera Remote Controllers	Panasonic WV-CR12
Ⓣ	VHS video playback	VHS Player	Panasonic AG-1150
Ⓤ	VHS video recording	VHS Recorder	Panasonic AG-2500
Ⓥ	9-pin computer input	DB-9 jack (video panel)	---
Ⓦ	Composite video input	BNC jack (video panel)	---
Ⓧ	RGB computer inputs	BNC jacks (video panel)	---
Ⓨ	Select monitor display source	Toggle switch (video panel)	---

CODE	GENERAL FUNCTION	COMPONENT	MAKE & MODEL
(AA)	Remote control/audio inputs	Remote Plugs - wall box (for rear proj. console)	---
(BB)	Switched AC power for rear projection	AC power outlets	---
(CC)	To project 35mm slide	Slide Projector	Kodak III-AMT
(DD)	To project 16mm film	16mm Projector	Eiki ENT-0
(EE)	Instructor controls - front console	Audio & AC power components	Various
(FF)	Instructor controls - front console	Video Recording components	Various
(GG)	Instructor controls - front console	Video Display components	Various
(HH)	Display of video images on front screen	Video Projector	GE Imager 300
(II)	Display of video images	Video Monitors	NEC DM-2600A
(JJ)	Recording and display of instructional materials	Video Cameras (overhead & rear mounted)	Panasonic WV-D500C
(KK)	Instructor controls - front console	Video inputs & components	Various
(LL)	Generate EGA computer output	Computer	Zenith 248/12 PC

Figure 12

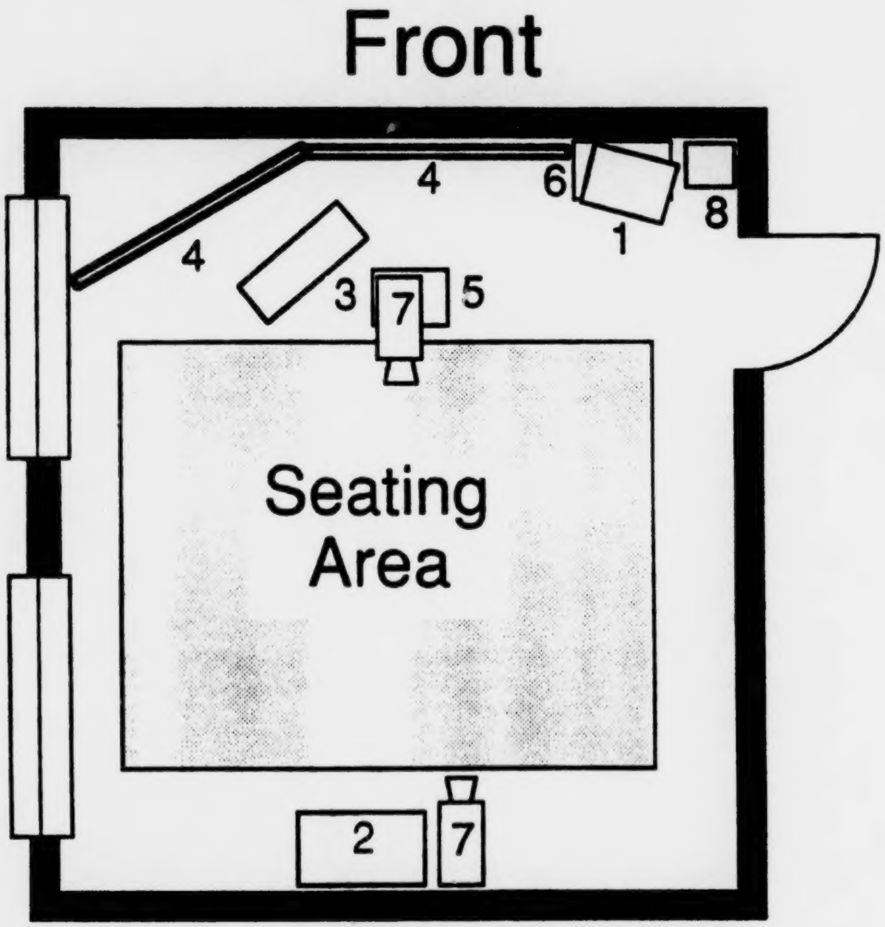
CATEGORY 2.


Front
6
1
4
1
6
3
5
2
1
Seating Area
Seating Area
5

1. Video Monitors
2. Slide/film Projection Systems
3. Overhead Projection &
   Instructor Work Station
4. Control Console
5. Video Camera Location
6. Audio Speakers

Figure 13

Category #3: Seminar Room



1. Video Monitor
2. Slide/film Projector Console
3. Overhead Projector
4. Screens, 70" & 84"
5. Instructor Work Station
6. Control Console:
    - audio panel
    - slide/film remotes
    - video camera controls
    - VCR/VP
    - computer
7. Video Camera Locations
8. Audio Speaker

Figure 14

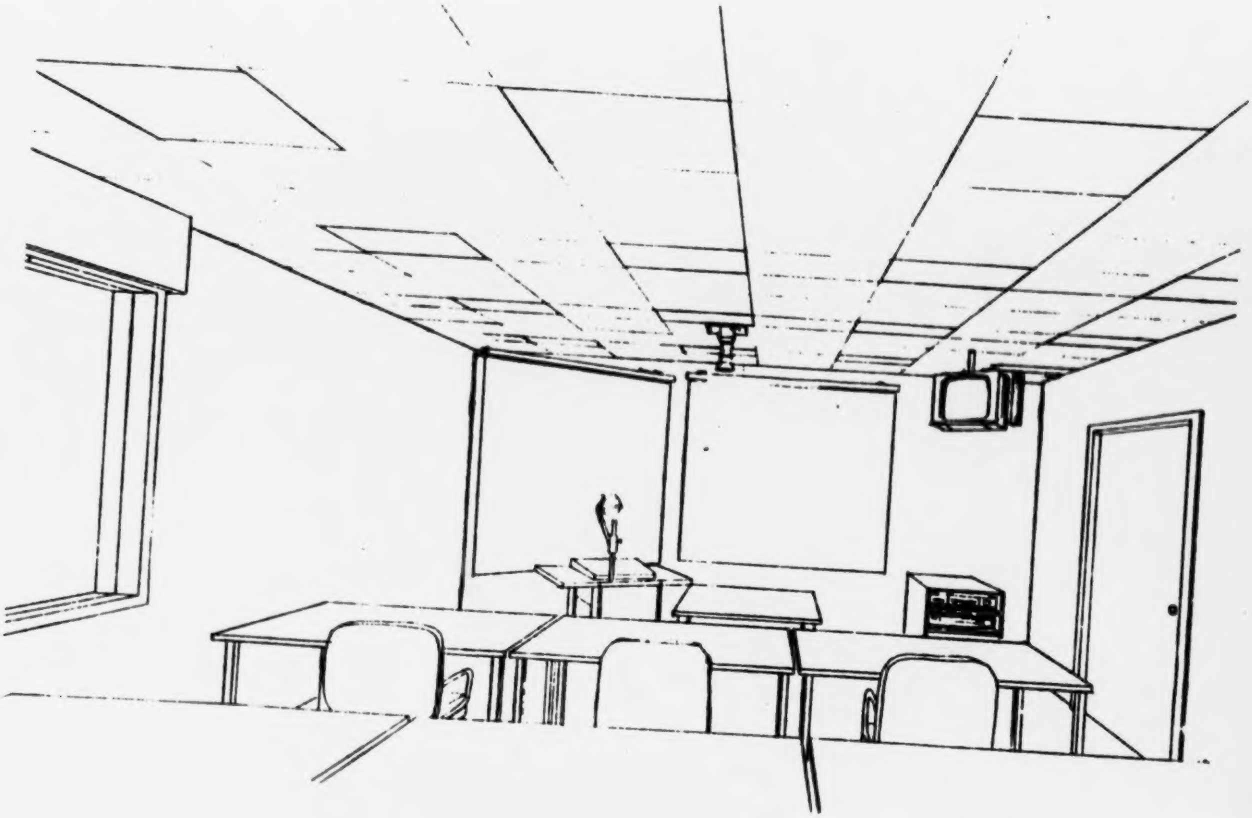
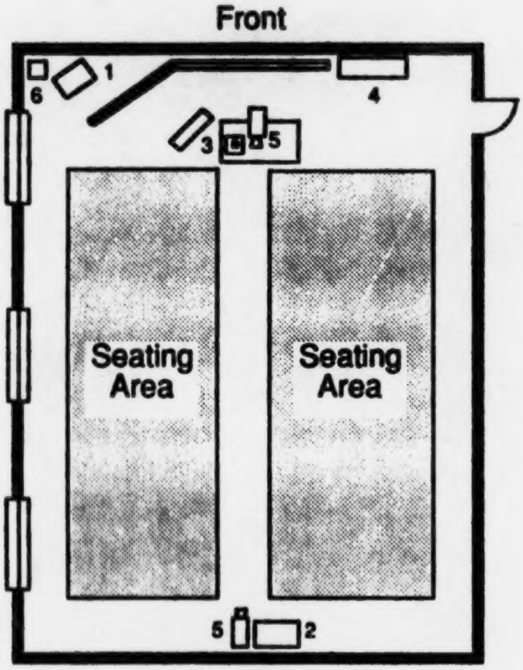


Figure 15

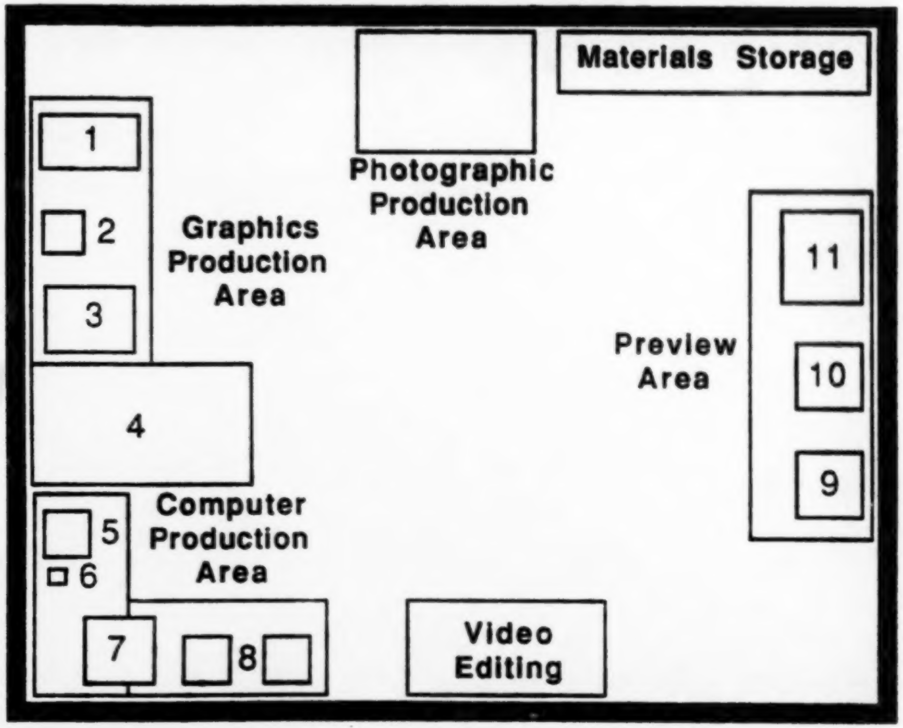
CATEGORY 4.


Front
1
6
4
3
5
Seating Area
Seating Area
5
2

1. Video Monitors
2. Slide/film Projection Systems
3. Overhead Projection & Instructor Work Station
4. Control Console
5. Video Camera Location
6. Audio Speakers

Figure 16

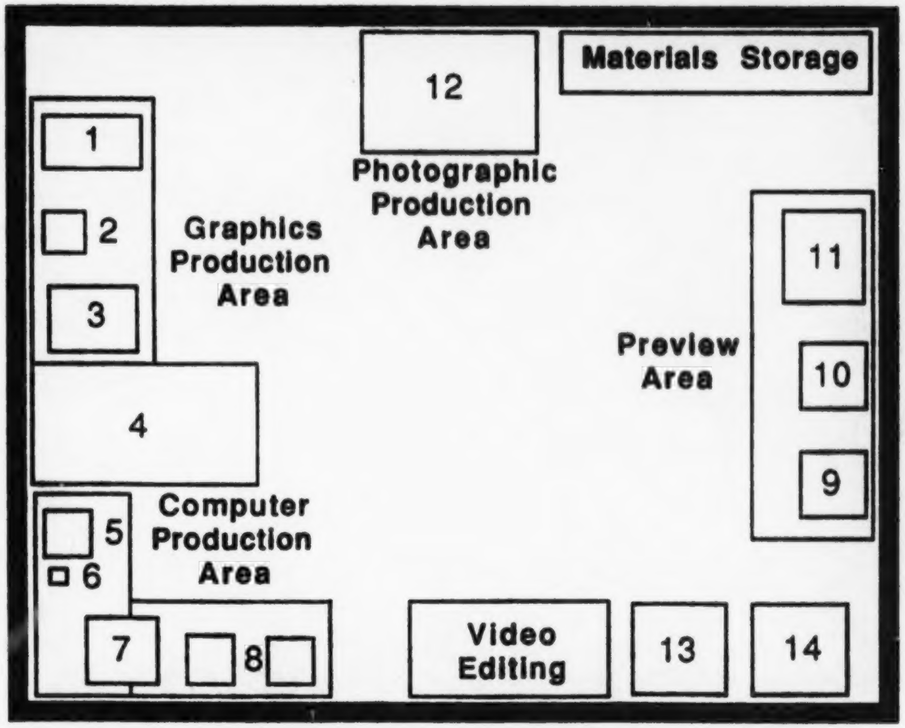
Satellite Media Production Center (SMPC)


Materials Storage
1
Photographic Production Area
2
Graphics Production Area
11
3
Preview Area
10
4
9
5
Computer Production Area
6
7
8
Video Editing

1. Laminator
2. TP Maker
3. Light Table
4. Layout & Drafting
5. Digitizer
6. Extension Drive
7. Laser Printer
8. Computers
9. Overhead
10. Slide/tape Preview
11. Video Player with T.V.

Figure 17

Prototype for the Central Media Production Center


Materials Storage
12
Photographic Production Area
1
2
3
Graphics Production Area
4
11
Preview Area
10
9
5
6
Computer Production Area
7
8
Video Editing
13
14

1. Laminator
2. TP Maker
3. Light Table
4. Layout & Drafting
5. Digitizer
6. Extension Drive
7. Laser Printer
8. Computer
9. Overhead
10. Slide/tape Preview
11. Video Player with T.V.
12. Copystand
13. Film-Video Transfer
14. PAL and SECAM Video Tape Equipment

Table 1: Design Plan Evaluation - Classroom Systems

	Classroom Systems	Average Rating
A.*	1. Proposal systems seem compatible with classrooms?	1.9
	2. The centralized control console for the system is appropriate?	2.23
	3. The proposed design plan meets my expectations?	1.54
B.**	The level of sophistication of the proposed systems seems:	6.31
C.***	Overall, I feel classroom presentation needs are being met.	2.09

---

* 14 Point Likert Scale Used

1 = strongly agree

4 = agree

10 = disagree

14 = strongly disagree

** 14 Point Likert Scale Used

1 = too high

4 = high but reachable

7 = about right

10 = low

14 = too low

*** 14 Point Likert Scale Used

1 = very adequately

4 = adequately

10 = inadequately

14 = very inadequately

Table 2: Design Plan Evaluation - Media Centers

	Classroom Systems	Average Rating
A.*	1. The proposal appears to provide adequate support?	4.0
	2. The proposed design plan meets my expectations?	2.75
B.**	The level of sophistication of the proposed systems seems:	6.17
C.***	Overall, I feel media production needs are being met.	2.75

---

* 14 Point Likert Scale Used
1 = strongly agree
4 = agree
10 = disagree
14 = strongly disagree

** 14 Point Likert Scale Used
1 = too high
4 = high but reachable
7 = about right
10 = low
14 = too low

*** 14 Point Likert Scale Used
1 = very adequately
4 = adequately
10 = inadequately
14 = very inadequately

Table 3: Evaluation of the Four Prototype Classroom Installations

	Question	Average Rating
A.*	1. Layout of the console is logical.	4.2
	2. Equipment pieces are easy to use and control.	3.2
	3. The prototypes perform adequately.	2.9
	4. The range of functions meets my expectations.	2.4
	5. The prototypes are a significant improvement over previous systems.	2.0
	6. The classroom-users manual is useful.	2.6
B.**	How often do you expect to use:	
	1. Screen projection equipment	1.4
	2. Audio playback and recording	5.6
	3. Video playback	2.8
	4. Video recording	3.3
	5. Computer display	5.1

---

* 14 Point Likert Scale Used

1 = strongly agree

4 = agree

10 = disagree

14 = strongly disagree

** 14 Point Likert Scale Used

1 = high use

4 = occasional use

10 = seldom use

14 = never use

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Title:

The Corporate College: Integrating Information Technologies

Author:

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THE CORPORATE COLLEGE:
Integrating Information Technologies

Summary

During the year since the founding of Squibb College, the Instructional Technology department has been charged with planning and implementing information technology systems for both office productivity and training. Decisions made, obstacles encountered, and progress achieved during that year are described.

The impact of the first year's experiences on future decisions is discussed. Major aspirations and challenges for the coming years are also outlined.

Background

Founded in September 1988, Squibb College was created by E.R. Squibb & Sons to meet the basic training, education, and development needs of its more than 20,000 employees worldwide. The initial mission statement of the College stressed the corporation's commitment to state-of-the-art technologies.

> The Squibb College will be the corporate umbrella for all training, education and development activities worldwide.
>
> The College will initiate and design management and career development programs as well as support special focus programs related to specific business units and functional responsibilities.
>
> Squibb College will ... integrate a worldwide state-of-the-art training technology ....
>
> The College is dedicated to supporting corporate goals by meeting the learning needs of its employees, enabling them to innovate and excel ....

-- Squibb College Mission Statement, 1988

Instructional Technology

To help fulfill that mission, the College established the Instructional Technology department, the first such function in the corporation. The mission of Instructional Technology is to serve the instructional systems development (ISD) needs of the College's curricular departments, such as Career/ Management Development. We also provide ISD services to various units outside the College organization, such as Pharmaceutical Group Sales Training.

Prior to the advent of the Instructional Technology department, training program directors had relied on external vendors and consultants for all training product development and for most design and delivery requirements. There had been no internal instructional developers and, thus, were no ISD tools. The new department was starting "from scratch."

The Technology Challenge

The Instructional Technology department did not really launch its activities until January 1989, just after Squibb College moved into a renovated training facility north of Princeton, New Jersey. At that time, we were assigned the task of integrating information technologies into the training development and delivery processes at Squibb College.

The creators of Squibb College agreed with Weiss and Birnbaum that "technical infrastructure is as important as communications and transportation in constraining or facilitating business activity" (1989, p.1015). Thus, because we were "the technology people" for the College, coordinating the selection and implementation of office automation systems was also among the responsibilities given to Instructional Technology.

Integrating Technologies for Productivity

When Squibb College first moved into its facility, fewer than half of the staff of 20 was equipped with an office microcomputer. The rest of the staff were recently hired to fill brand-new positions and, thus, brought no computing resources with them. Therefore, the first major challenge for the Instructional Technology group was to select and provide essential productivity tools for all College personnel, ensuring insofar as possible that the tools we chose would serve the College well for up to three years.

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Decisions

> Long-range planning does not deal with future decisions, but with the future of present decisions.

-- Peter Drucker

It was immediately evident that much time, energy, and paper could be saved by linking everyone through a local-area network (LAN). For example, we estimated a time saving of 70% in scheduling meetings alone, through the use of the "Scheduler" feature of WordPerfect Office, the corporate standard for LAN-based menu interface.

Hardware decisions were fairly easy, because few options were available to us within the limits of the corporate standards laid down by Squibb's Information Resources group. For example, the LAN specifications were predetermined. We did select a basic desktop system for each staff member and, for users whose activities demand greater computing power or greater variety of capabilities, a range of options. All of these hardware selections are shown in Table 1.

(Table 1 about here)

Based on a careful task analysis of Squibb College activities, standard, LAN-based, productivity software was selected from those packages formally approved as corporate standards. This was a more difficult, more time-consuming analysis, encompassing as it did several departments varying greatly in the complexity of their needs. The range of basic software purposes, our selected tools, and typical College applications are summarized in Table 2.

(Table 2 about here)

Implementation

> The art of progress is to preserve order amid change and to preserve change amid order.

-- Alfred North Whitehead

Because of Squibb's extensive request-approval-implementation process, we implemented our productivity technologies in two manageable, orderly phases: first, stand-alone systems; second, the LAN.

Implementing stand-alone systems first allowed College personnel to begin learning fundamental computer operations and software packages almost immediately, so that they could become productive quickly. To avoid unnecessary duplication of expenditures for both single-user and network versions of software, at this stage we provided single-user copies of only the most basic software packages - WordPerfect, Lotus 1-2-3, and a few special packages for certain users.

As it happened, our implementation plan was fortuitous. A sequence of approval delays pushed the implementation of the LAN back to December 1989/January 1990. Had we elected to implement the network immediately, we might have been without computational power for a year!

Integrating Technologies for Training

The second major challenge for Instructional Technology was planning and implementing the rational integration of technologies into training curricula, with particular emphasis on Pharmaceutical Group Sales Training.

Decisions

In the beginning, most instruction at Squibb College was traditional "stand-up" training, using flipcharts, overhead and slide projectors, and linear videotapes. Trainers had occasionally employed a variety of other technologies: optical scanners, interactive keypads, computer-based testing. Sales trainers, in particular, were pleased with the versatility provided by computer-controlled media, and were eager to integrate additional innovative technologies into their training programs.

Of all instructional technologies available early in 1989, the greatest learning gains and instructional variety were achievable through interactive videodisc. Information Resources had a corporate standard for that, too: IBM InfoWindow units using SONY LDP-2000 laser videodisc players. We therefore designed an Interactive Learning Center at Squibb College that would consist of eight to twelve networked IBM PS/2 Model 50Zs, with InfoWindow touch-screen monitors and SONY videodisc players. Other peripherals, such as videotape players and interactive keypads would be controlled, as desired, by the PS/2 computers.

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Dissemination of independent-study programs to employees at other Squibb sites was also a concern for Instructional Technology. We recommended that each sales distribution center and each major employee center in the USA be provided with two InfoWindow units that would run the programs we were creating.

Squibb's European operations, however, could not use IBM InfoWindow systems, because the NTSC video convention used in the USA is incompatible with the PAL and SECAM video conventions used in Europe. For these operations, we were initially forced to consider transferring programs to other media, such as simple computer-based training or linear videotape. Fortunately, dual-standard interactive systems are now available, so the sharing of training programs with our colleagues is no longer an insurmountable problem.

The selection of ISD software has been more difficult. Certainly, our choice of delivery system somewhat limited our software options. Early in 1989, only InfoWindow Presentation System (IWPS) and Learning System 1 (LS/1) authoring systems were available for IBM InfoWindow (of these two, we preferred IWPS, although neither met our needs).

Also limiting were the software choices made by the vendors who created programs for Squibb College, because we would have to be able to revise and update such programs. For example, an extensive computer-based testing program was prepared using TenCore; a career development program was created using Summit; an employee information program was designed with IWPS. We realized that we would have to purchase all of these authoring systems (for maintenance), as indicated in Table 3.

(Table 3 about here)

As the number and capabilities of authoring systems has increased, Instructional Technology's task has become simultaneously easier and more difficult. We can now find authoring systems with the functions we desire; however, these systems may not run on our corporate standard hardware. We are still evaluating authoring software ... and will probably be doing so for yet another year!

Implementation

Late in 1988, Pharmaceutical Group Sales Training had purchased five InfoWindow units (with IBM AT microcomputers). These units formed the foundation of the Squibb College Interactive Learning Center. To these, Instructional Technology added six InfoWindow units (with IBM PS/2 microcomputers), one of which was ear-marked for ISD work. Our hopes to network the units have not yet been realized, nor have funds been available to purchase units for other sites. Programs available in the Interactive Learning Center for independent study are now fully employed throughout Pharmaceutical Group Sales Training. These include computer-based testing and games, sales and patient-management simulations, and complex videodisc-based instructional programs. In addition, interactive keypads, interactive games, and videodisc-based simulations have been integrated into classroom training.

Although most training is still conducted in the traditional manner, we are pleased that the integration of technologies into training at Squibb College has not stopped with Sales Training. Our Orientation Program for New Employees now encompasses an interactive-videodisc program, "Orientation to Squibb Cardiovascular Products." This two-hour program is available on InfoWindow units that we have provided at five Squibb locations in addition to the College itself. To accomplish this, we transferred the five original InfoWindow units to other sites, leaving just the six "new" units at the College.

Our colleagues in Europe have received little help from us so far. However, they are evaluating the comprehensive computer-based testing program, with the intention of translating it into French, German, and Italian. The adoption or adaptation of other individualized programs is awaiting the availability of the new dual-standard systems.

Information Technologies and Future College Operations

In October 1989, E.R. Squibb & Sons merged with Bristol-Myers Company to form Bristol-Myers Squibb Company, the second-largest pharmaceutical company in the world. A merger of this magnitude provides extraordinary business opportunities for a corporation, but also brings reorganization and redefinition of roles within the corporation.

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Instructional Technology's Role in the New Corporation

> The new circumstances under which we are placed call for new words, new phrases, and for the transfer of old words to new objects.
>
> -- Thomas Jefferson

As of this writing (January 1990), the role of Squibb College (likely to be called "Bristol-Myers Squibb College") within the new corporation has not been finalized. Undoubtedly, we will retain some aspects of our former mission, but different areas of responsibility may be included. Instructional Technology will continue to contribute to the achievement of the College's mission.

We will likely de-emphasize technological innovation during the coming year, in favor of assessing the effectiveness of current practices. During this period, we will have the time to achieve benefits from the decisions and investments we have already made, and to make maximum use of those productivity and development tools we now possess.

Productivity

In the area of office automation, implementation of the LAN will allow the College to realize the productivity gains Instructional Technology promised would come about through the use of Scheduler, e-mail, and shared files.

We will fully implement desktop publishing for the first time, producing manuals and newsletters in-house. And will produce most of our own business graphics for overhead transparencies and reports.

Disseminating Training

It will continue to be very important that we disseminate training products to corporate locations throughout the USA and Europe, especially to Sales Training groups. However, we will concentrate on less expensive, more portable technologies than IBM InfoWindow has proven to be.

The technologies we currently favor for the coming years are: audiotape, videotape, computer-based training/testing, and compact-disc interactive systems (using Digital Video Interactive technology). With these, Instructional Technology can still achieve our instructional goals, but gain levels of acceptance and implementation that eluded us this past year.

> The seasons have changed
> And the light
> And the weather
> And the hour.
> But it is the same land.
> And I begin to know the map
> And to get my bearings.

-- Dag Hammarskjöld; August 24th, 1961

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Peter, L.J. (1977). Peter's quotations: Ideas for our time. New York: Bantam Books.

Weiss, A.R., & Birnbaum, P.H. (1989). Technological infrastructure and the implementation of technological strategies. Management Science, 35, 1014-1026.

Lan Specifications:

IBM Token Ring LAN
STF Netware 286, v.2.15
Proteon Intelligent Multistation Access Units
Microcom QX/V.32C Modem
HP LaserJet IID Printers
HP Color Plotter

Basic Desktop System:

IBM PS/2 Model 50Z, with 30 MB hard disk
and 1.44 MB 3½-inch disk drive
IBM 8512 VGA Monitor
Intel 80287 Math Coprocessor

Hardware Options (for more sophisticated applications):

IBM PS/2 Model 80, with 115 MB hard disk
and 1.44 MB 3½-inch disk drive
IBM 8514/A VGA Monitor
Intel 80387 Math Coprocessor
Microsoft 2-button Mouse
Hayes SmartModem 2400, with SmartCom II
HP LaserJet II Printer
HP DeskJet Printer

TABLE 1 College Hardware Systems

Purpose	Tools	Applications
Word processing	WordPerfect, v.5.1, with Bitstream fonts and clip art	Correspondence and documents, including macros; desktop publishing
Financial analysis	Lotus 1-2-3, v.3.0	Budgets; data display
Data storage and retrieval	dBASE IV	Vendor information system
Graphics	Freelance Plus, v.3.0	Overhead transparencies; desktop publishing
Project management	TimeLine, v.3.0	Project management; load analysis
Communications	Smartcom II, v.3.0	BBS access; BITNET communications
Utilities	WordPerfect Office	Appointment calendars; meetings scheduling; e-mail; simple databases; file management; "to-do" lists; calculator

TABLE 2 Productivity Software

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Purpose	Tools	Applications
Student registration, administration	Registrar/N, with Accountant, Scheduler, Historian/N, T&D Analyzer	Registration; delivery costs; course and room scheduling; student records
Testing	TenCore, Multi-Survey/Feud/Pursuit	Computer-based testing and games
Authoring	IWPS; Summit	Interactive training programs
	Shell	Employee information programs

TABLE 3 Training Software

Title:

Instructional Design Theory: Advancements from Cognitive Science and Instructional Technology

Author:

Robert D. Tennyson

Instructional Design Theory:

Advancements from Cognitive Science and Instructional Technology

Scientific advancements in cognitive science and instructional technology suggest significant changes in methods of curricular and instructional design which will strongly affect educational practice. These advancements extend the predominately applied behaviorally-oriented learning paradigm of instructional design and management. In this article I will discuss three major areas in which cognitive science and instructional technology are affecting instructional design (ID) theory. These are: (a) the analysis of the information-to-be-learned; (b) the means of evaluating learners; and, (c) the linkage of learning theory to instructional prescriptions.

Analysis of Information-to-be-Learned

An important component of ID models is the analysis of the information-to-be-learned. Two basic types of analyses include: (a) a content analysis, that focuses on defining the critical features of the information and the relationship of those features according to superordinate and subordinate organizations; and (b) a task analysis, that focuses on a hierarchial organization of the information based on prerequisites. Both of these analyses identify the external structure of the information but do so independent of how it might actually be stored in human memory. However, research in cognitive psychology on human memory suggests that the internal organization of information in a knowledge base is based more on employment needs than by attribute or hierarchial associations. That is, the utility of the knowledge base is attributed to its organization not the amount of information. The implication of knowledge base organization is the need for a

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further analysis of the information to better understand the possible internal organization of the information. Better organization in memory may also imply better accessibility within the knowledge base for such higher order cognitive activities as problem solving and creativity.

To understand the nature of knowledge base organization, cognitive psychologist analysis problem complexity and the way individuals try to solve given problems. By analyzing problems, it is possible to identify the concepts employed; and, by analyzing the solutions, it is possible to identify the associations of those concepts within given problem situations. The implication for ID is that the sequence of information for instruction should be based in part on internal associations as well as external structures. The assumption is that because external structures are independent of employment needs, an analysis of possible internal associations would improve the initial organization of the new information.

In addition to the analyzing of problems and solutions, is the issue of problem context. For example, expert systems reside within the constraints of a specific context: That is, they can solve problems only associated with that given context. Likewise, research in cognitive psychology shows that individuals can solve complex-problems only if they poses the necessary contextual knowledge (i.e., knowledge of when and why). For example, the objective in learning to play chess is the learning of problem solving strategies within the context of both the given game and the current move: not just how the various chess pieces move (i.e., procedural knowledge). Thus, the key to both effective acquisition and employment of knowledge is the organization of the information according to contextual applications.

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The change for content/task analysis suggested by cognitive science is the method of information analysis. In addition to the conventional content and task analyses, a context analysis is proposed if the goal of the instruction includes solving complex-problems. Basic steps for a context analysis are as follows:

-Define the context for the employment of the knowledge.

-Define the complex-problems associated with the context.

-Analysis solutions to identify concepts employed.

-Cluster the concepts according to employment.

-Organize the clusters into an associative network.

Analyzing problems within a context and then identifying the concepts and their employment organization provides a means for sequencing the instruction to improve higher order cognition. In other words, the sequence of the instruction is based on the objective of improving employment of knowledge in addition to improvements in acquisition.

Learner Evaluation

A second major area being affected by cognitive psychology is learner evaluation. In the behavioral paradigm, evaluation focuses only on observable student performance while, in contrast, evaluation in the cognitive paradigm takes on diagnostic functions. Evaluation is therefore more than checking attainment of behavioral objectives but, more importantly, a concurrent element of learning. For example, diagnosing learner needs during instruction has been a primary focus of empirical research that my colleagues and I have been working on for the past two decades. (A review of this program of research in

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adaptive instruction is found in Tennyson and Christensen [1988] and Tennyson and Park [1987]).

Much of the experimental programming efforts in intelligent computer-assisted instruction (ICAI) centers on techniques to identify mistakes and errors in solving problems (Dehn & Schank, 1982). Although not adaptive in preventing learning problems, ICAI programs are advancing the concept of finding possible problems and trying to help the student by prescribing specific instruction.

In the field of measurement, contemporary research is with design of instruments that measure inference making within meaningful contexts. The implication for instructional design is the construction of tests that evaluation problem solving within complex-context situations: Situations that go beyond the usual limited scope of measuring only right and wrong responses.

The implications for instructional design are in the cognitive paradigm concepts of (a) diagnosis of learning need during instruction and (b) measures of achievement within the context of meaningful and complex situations. That is, can the learner deal successfully with the type of problems requiring knowledge of when and why as well as knowing that and how.

Integrated Instructional Design Model

In this section I present a third area of cognitive psychology and instructional technology influences on ID theory: The development of an instructional design model that focuses on the planning of a learning environment so that students not only acquire knowledge but also improve their cognitive abilities to employ and extend their knowledge. In Figure 1, I present an instructional design model that shows the direct integration of cognitive learning theory with prescribed instructional strategies. In addition to the direct linkages between the various memory systems and instructional strategies, I propose that 70% of formal, classroom learning time use instructional prescriptions that focus on employing and improving knowledge. The major components of the ID model are: memory systems, learning objectives, instructional time, and instructional prescriptions. These are now discussed in turn.

Insert Figure 1 about here

Memory systems. The proposed ID model is directly associated to the cognitive paradigm of learning. A complete discussion of this paradigm is fould in Tennyson and Rasch (1988). Because the goals of the ID model include both the acquisition and the employment of knowledge, the memory systems reference the long-term memory subsystems of storage and retrieval. The storage system is composed of three basic forms of knowledge: Declarative knowledge, knowing "that" about the information; procedural knowledge, knowing "how" to use information; and, contextual knowledge, knowing "when and why" to use given information. The retrieval system is composed of cognitive abilities associated with the processes of recall, problem solving, and creativity.

Proposed in the ID model (see Figure 1) is that there is a connection between the five basic memory systems and prescribed instructional strategies. The purpose for including this component in the ID model is twofold: First, to establish a direct link between instructional theory and learning theory: This was done successfully with the behavioral paradigm where instructional strategies were designed following the conditions of that paradigm. Thus, I have attempted in this article to make an association between the cognitive paradigm and instructional strategies. And, second, to indicate the relative strengths of the instructional strategies in reference to the educational goals of knowledge acquisition and employment. The focus of the cognitive paradigm is on both of these educational goals as contrasted to the behavioral paradigm which only concerns itself with the acquisition goal. Within the proposed ID model, the learning objectives extend the macro level goals so as to tie directly with the memory systems component.

Learning objectives. The purpose of cognitive-based learning objectives is to further elaborate the curricular goals of knowledge acquisition and employment. Objectives are important in the planning of learning environments because they provide the means of both allocating instructional time and identifying specific instructional strategies. I define learning objectives as follows:

-Verbal information. This objective deals with the learner acquiring an awareness and understanding of the concepts, rules, and principles within a specified domain of information (i.e., declarative knowledge).

-Intellectual skills. This objective involves the learner acquiring the skill to correctly use the concepts, rules, and principles of a specified domain of information (i.e., procedural knowledge).

-Contextual Skills. This objective focuses on the learner's acquisition of a knowledge base's organization and accessibility (i.e., contextual knowledge). The organization of a knowledge base refers to the schematic structure of the information whereas the accessibility refers to the executive control strategies that provide the means necessary to employ the knowledge base in the service of recall, problem solving, and creativity. Contextual knowledge includes the criteria, values, and appropriateness of a given domains schematic structure. For example, simply knowing how to classify examples or knowing how to use a rule (or principle) does not imply that the learner knows when and why to employ specific concepts or rules.

-Cognitive strategies. This objective deals with both the development of cognitive complexity abilities and the improvement of domain specific strategies of thinking. Thus, this category of learning objectives deals with two important issues in education. First, the elaboration of thinking strategies that will arm the students with increased domain specific contextual knowledge. Second, the development of the cognitive abilities of differentiation and integration. These abilities provide the cognitive tools to effectively employ and improve the knowledge base; therefore, they are integral to any educational goal seeking to improve thinking strategies.

-Creative Processes. This objective deals with the most elusive goal of education: the development and improvement of learner creative abilities. I define creativity as a two fold ability: First, creating knowledge to solve a problem from the external environment; and, second, creating the problem as well as the knowledge. Integral to the creating of both the problem and knowledge is the criteria by which consistent judgement can be made. I define two forms of criteria as follows: The first is criteria that are known and which can be applied with a high level of consistency. In contrast are criteria that are developed concurrently with the problem and/or knowledge, and is consistently applied across a high level of productivity. Creativity objectives need to specify not only the ability to develope and improve, but also the form of criteria. That is, students should be informed of the criteria in the former and, in the latter, the necessity to develop criteria.

Instructional time. A key factor in implementing the cognitive goals of knowledge acquisition and employment is the allocation of learning time by defined objectives. For example, Tennyson and Rasch (1988) suggest that if improvements in problem solving and creativity are to occur, there needs to be a significant change in how instructional time is allocated. They recommend that the conventional instructional time allocation for learning be altered so that, instead of 70% of instruction aimed at the declarative and procedural knowledge levels of learning, 70% be devoted to learning and thinking situations that involve acquisition of contextual knowledge and development of cognitive abilities.

Using Tennyson and Rasch's recommended figures on instructional time allocation, I propose that learning time be divided between the two main subsystems of long-time memory—storage and retrieval. Within the guidelines illustrated in Figure 1, time is assigned according to the cognitive objectives defined in the previous section. In the storage system, learning time is allocated among the three memory systems making up a knowledge base as follows: declarative knowledge 10%; procedure knowledge 20%; and contextual knowledge 25%. I am recommending that contextual knowledge learning time be about equal to the other two knowledge forms because of the necessity to both organize a knowledge base and develop accessibility. The value of a knowledge base is primarily in the functionality of its organization and accessibility . Without a sufficient base of contextual knowledge, the opportunity for employment, future elaborations, and extension of the knowledge base is severely limited.

For the knowledge acquisition goal, the focus of learning time allocation is on contextual knowledge, and away from the usual practice of heavy emphasis on amount of information. I am assuming that declarative and procedural knowledge acquisition is an interactive process that is improved when employing the knowledge base in the service of higher-order thinking situations (i.e., problem solving and creativity). Time allocated for declarative and procedural knowledge focuses on establishing an initial base of necessary knowledge that can be used within a context of a problem situation. That is, learning time should include the opportunity for the learner to gain experience in employing the knowledge.

The learning times presented in Figure 1 do not imply a linear sequence of knowledge acquisition going from declarative to contextual. Rather, they represent total amounts in an iterative learning environment where learners are continuously acquiring each form of knowledge. For example, students may engage in contextual knowledge acquisition prior to declarative knowledge acquisition if they currently have sufficient background knowledge (i.e., a discovery method of instruction as contrasted to a structured method).

Instructional prescriptions. The purpose of the proposed ID model is the direct linkage of instructional strategies to specific memory system components. Also, instead of prescribing a given strategy of instruction for all forms of learning, I have identified general categories of strategies, each composed of variables and conditions that can be manipulated according to given instructional situations.

The five instructional strategy categories are as follows:

Expository strategies. This category represents those instructional variables designed to provide an environment for learning of declarative knowledge (see Figure 1). The basic instructional variables provide a context for the to-be-learned information. That is, the concept of advance organizers is extended by presenting a meaningful context for the information as well as a mental framework of the given domains abstract structure. In addition to providing a context for the information, meaning can be further enhanced by adapting the context to individual student background knowledge (Ross, 1983).

The context establishes not only the initial organization of the domain but, also, introduces both the "why" of the theoretical nature of the information and the "when" of the criterion nature of the domains standards, values, and appropriateness. Personalizing the context to student background knowledge improves understanding of the information by connecting, within working memory, knowledge that is easily retrieved. Thus, the new knowledge becomes directly linked or associated with existing schemas.

Following the contextual introduction of the information, additional expository instructional variables present the ideas, concepts, principles, rules, facts, etc. in forms that extend existing knowledge and that aid in establishing new knowledge. These variables include:

-Label. Although a simple variable, it is often necessary to elaborate

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on a label's origin so that the student is just not trying to memorize a nonsense word.

-Definition. The purpose of a definition is to link up the new information with existing knowledge in long-term memory; otherwise the definition may convey no meaning. That is, the student should know the critical attributes of the concept. To further improve understanding of the new information, definitions may, in addition to presentation of the critical attributes (i.e., prerequisite knowledge) include information linked to the student's background knowledge.

-Best Example. To help students establish clear abstracts of a domain's concepts, an initial example should represent an easy comprehension of the given concept (or rule, principle, idea, etc.). Additional expository examples will enhance the depth of understanding.

-Expository Examples. Additional examples should provide increasingly divergent applications of the information; perhaps also in alternative contexts).

-Worked Examples. This variable provides an expository environment in which the information is presented to the student in statement forms that elaborate application. The purpose is to help the student in becoming aware of the application of the information within the given context(s). For example, to learn a mathematical operation, the student can be presented the steps of the process in an expository problem while, concurrently, presenting explanations for each step. In this way, the student may more clearly understand the procedures of the mathematical operation without developing possible misconceptions or overgeneralizations.

Practice strategies. This category of instructional prescriptions contains a rich variety of variables and conditions which can be designed into numerous strategies to improve learning of procedural knowledge. This category is labelled practice, because the objective is to learn how to use knowledge correctly; therefore, it requires constant interaction between student learning (e.g., problem solving) and instructional system monitoring. Practice strategies should attempt to create an environment in which (a) the student learns to apply knowledge to previously unencountered situations while (b) the instructional system carefully monitors the student's performance so as to both prevent and correct possible misconceptions of procedural knowledge.

The basic instructional variable in this strategy is the presentation of problems that have not been previously encountered (see Tennyson & Cocchiarella, 1986, for a complete review of variables in this category). Other variables include means for evaluation of learner responses (e.g., pattern recognition), advisement (or coaching), elaboration of basic information (e.g., text density, Morrison et al., 1988), format of information, number of problems, use of expository information, error analysis, and lastly, refreshment and remediation of prerequisite information.

Problem-oriented strategies. In the proposed ID model (Figure 1), I propose that 25% of the instructional time be allocated to the acquisition of contextual knowledge. A proposed instructional strategy for this category uses problem-oriented simulation techniques. The purpose of simulations is to improve the organization and accessibility of information within a knowledge base by presenting problems that require the student to search through their memory to locate and retrieve the appropriate knowledge to propose a solution. Within this context, the simulation is a problem rather than an expository demonstration of some situation or phenomenon.

Problem-oriented simulations present domain specific problem situations to improve the organization and accessibility of information within the knowledge base. Basically, the strategy focuses on the students trying to use their declarative and procedural knowledge in solving domain-specific problems. Problem-oriented simulations present problem situations that require the student to (a) analyze the problem, (b) work out a conceptualization of the problem, (c) define specific goals for coping with the problem, and (d) propose a solution or decision. Unlike problems in the practice strategies that focus on acquiring procedural knowledge, problem-oriented simulations present situations that require employment of the domain's procedural knowledge. Thus, the student is in a problem solving situation that requires establishing connections and associations among the facts, concepts, rules, and principles of specific domains of information.

Complex-dynamic strategies. Employment of the knowledge base in the service of recall, problem solving and creativity is the second major educational goal of learning environments. In contrast to instructional systems that use domain-independent thinking skills development, this instructional strategy category proposes the presentation of domain-specific situations that allow learners to develop their thinking processes while employing the domain knowledge stored in their own memory systems. As such, complex-dynamic simulations extend the format of the problem-oriented simulations by use of an iterative format that not only shows the consequences of decisions but also updates the situational conditions and proceeds to make the next iteration more complex. That is, the situation is longitudinal, allowing for increasing difficulty as well as providing additions, deletions, and changes in variables and conditions. In sophisticated complex-dynamic simulations these alterations and changes are done according to individual differences (Breuer, 1987).

The main features of complex-dynamic simulations are: (a) present the initial variables and conditions of the situation; (b) assess the learner's proposed solution; and (c) establish the next iteration of the variables and conditions based on the cumulative efforts of the learner (Breuer & Kummer, in press).

In summary, complex-dynamic strategies should be designed to provide a learning environment in which learners develop and improve higher-order thinking processes by engaging in situations that require the employment of their knowledge base in the service of problem solving.

Self-directed experiences. The creative process is a cognitive ability that seemingly can be improved by learners who engage in activities requiring novel and valuable outcomes. That is, the creative process can be improved by instructional methods that allow students the opportunity to create knowledge within the context of a given domain. Instructional programs that provide an environment for easy manipulation of new information increase the learning time available for such activities.

Computer-based software programs provide environments for self-directed learning experiences that may improve the creative process within given domains. For example, word processing programs have been shown to improve writing skills because of the ease in correcting and adjusting text structure (Lawler, 1985; Zvacek, 1988). Computer-based simulations have also shown that the creative process can be improved when students can both continually see the outcomes of their decisions while understanding the predictability of their decisions (Rasch, 1988).

The creative process is a cognitive ability that apparently can be improved with use within a domain and computer-based software programs seem to provide the type of environment which can enhance instructional methods for such improvements. Because of the time necessary for participating in creative activities, educators should provide sufficient learning time for such development (Tennyson, 1988). Computer software programs that are domain specific enhance the cost-effectiveness of instructional strategies aimed at the improvement of creativity.

The key instructional attribute for this category is an environment that allows students to experience the creative process at that given moment. Computer software programs that are domain specific and provide for self-directed learning seem to offer excellent instructional strategies for meeting goals of a curriculum that emphasizes higher-level thinking strategies. Although, we have focused on computer-based software in this instructional category, there are of course other possible instructional means for students improving their creative processes.

Conclusion

The purpose of this article was to discuss several areas in which recent advancements in cognitive psychology and educational technology may affect instructional design theory. The first two areas, information analysis and learner evaluation, proposed extensions to current methods of instructional development. Information analysis proposes an additional analysis of the information based upon complex-problems associated with a given context. Whereas, a conventional content/task analysis identify the attributes of the information, the context analysis identifies the schematic organization of the information. The schematic organization improves the service of the knowledge base for higher level employment situations (i.e., problem solving and creativity).

The effect of cognitive psychology on learner evaluation deals with two fundamental aspects of evaluation. First, when do it and, second, what to measure. For the former aspect of when, it is proposed that evaluation be of a diagnostic nature, occurring during learning. Diagnosing learning need while learning would improve the instructional prescription. That is, the instructional program would be adjusting to current individual needs and differences. For the latter aspect, the focus of evaluation would be on higher order inference making both within specific domains and cognitive abilities.

The third area proposed the framework for an ID model that directly links cognitive learning theory with specific instructional strategies. I also proposed that learning time be allocated according to the educational goals of knowledge acquisition and employment. Given the assumption that learners can elaborate and extend their knowledge base during employment, instructional time was shifted from the traditional allocation of 70% for acquisition to 70% for improvements in employment. This reallocation of instructional time does not reduce the importance of content, but places more of the burden of acquisition on the learner. Rather than acquisition of knowledge in nonsense isolation, it is proposed that learners acquire knowledge within meaningful situations. Unfortunately, research in instructional theory has focused on strategies associated with declarative and procedural knowledge with minimal empirical work for strategies associated with contextual knowledge and cognitive abilities. Educational technology should provide the means by which cognitive psychology can be applied to improvements in learning. That is, the behavioral paradigm was implemented by means of educational technology, I see the same thing happening for cognitive psychology.

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Figure Captions

Figure 1. Instructional design model linking cognitive learning theory with instructional prescriptions.

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ID Model Components	Educational Goals				
	Acquisition of Knowledge		Employment of Knowledge		
Memory Systems	Declarative Knowledge	Procedural Knowledge	Contextual Knowledge	Cognitive Complexity	Total Cognitive System
Learning Objectives	Verbal Information	Intellectual Skills	Contextual Skills	Cognitive Strategies	Creative Processes
Instructional Times	10%	20%	25%	30%	15%
Instructional Prescriptions	Expository Strategies	Practice Strategies	Problem-Oriented Strategies	Complex-Dynamic Strategies	Self-Directed Experiences

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Title:

A Review of Embedded Training: "Status and Emerging Role in Training"

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A Review of EMBEDDED TRAINING:
"Status and Emerging Role in Training"

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Recent advances in computers have provided capabilities to develop sophisticated simulators for training and embedding the training within operational equipment. Embedded training is an emerging trend in military education. The use of simulators and embedded training (ET) has increased for training of pilots, weapon systems, etc. Some of the reasons for this are cost, safety, practice time, and the ability to train in adverse conditions at any time. The effectiveness of simulators and ET is measured by level of fidelity, cost, feedback, transfer of training to the operational equipment, and increase in skill level. This paper reports an investigation into the direction that embedded training is taking and examines lessons learned about the when and how to implement embedded training.

The purpose of training devices and embedded training is twofold: first, to provide opportunities for the student to practice his/her job performance, and; secondly, to provide original learning opportunities for the students. The term "Embedded Training" (ET) has been defined as training that is provided by capabilities designed to be built into or added onto operational systems to enhance and maintain the skill proficiency necessary to operate and maintain that equipment end item (1:4-8).

ET has several advantages over the traditional approaches of either supervised OJT (on-the-job training) or CBT (computer-based training) using stand-alone personal computers (PCs). First, embedded training allows immediate hands-on experience with the operational system. Second, ET provides self-paced practice in critical, hard-to-master skills without the man-intensiveness of over-the-shoulder tutoring. Finally, by stimulating actual workstation equipment, the embedded training component can provide the learner with realistic, system-specific cues, responses, and information. Additionally, since it can use actual operational system data, it can provide a mechanism for skill qualification testing that is site-specific or operational-specific rather than generic.

Several types of tasks are better candidates for training via ET. These are summarized in Figure 1. Generally it is more appropriate to training tasks via ET which require higher level cognitive skills, the integrated performance of multipple skills, or team training. Tasks which are primarily rote actions or which require only lower levels of cognitive activity are poorer candidates for inclusion in ET.

GOOD EMBEDDED TRAINING CANDIDATES	POOR EMBEDDED TRAINING CANDIDATES
• TEAM COOPERATION TASKS	• ROTE PRECEDURES
• UTILIZATION OF RULES OR CONCEPTS	• BASIC KNOWLEDGE
• PERFORMANCE OF VARIABLE OR CONTINGENCY PROCEDURES	• BASIC LEVEL BEHAVIORS/SKILLS
• PERFORMANCE OF INTEGRATED MULTIPLE SKILLS	

Figure 1. Task/Embedded Training Suitability

The basic technology for ET is computer-based. Any control system which is digital in format and can provide sufficient memory, processing, and storage to handle the training database is a candidate for embedded training. ET concepts are still in an infancy stage when compared to advances in technology which might be utilized for ET. While ET has been utilized by the military on isolated projects for over 30 years, only recently has direction been given to thoroughly evaluate and consider ET as the preferred training alternative. ET is now specified as the preferred training alternative for the design & development of training subsystems in the development and follow-on Product Improvement Programs of all Army materiel systems by the Joint Chiefs of Staff (JCS).

Several types of training objectives have been identified which more appropriately lend themselves to an Embedded Training approach. Generally tasks can be identified as appropriate for ET based on their criticality and perishability (2: 17ff). Criticality is a valuative judgement on the consequences on inadequate or slow task performance. Perishability is a rating indicating the skill decay rate of a component skill including decay of the ability to perform tasks or objectives which are dependent on that skill. Generally tasks which require the performance of integrated multiple-skills (high-workload, demanding components of performance), the utilization of rules or concepts (complex cognitive tasks), and the performance of variable or contingency procedures (requiring flexible, mediated responses) are more suitable for Embedded Training. Figure 2 summarizes primary ET task selection factors. Tasks which involve rote or invariate procedures, basic manipulative skills, factual knowledge, and basic level behaviors are usually less suitable for inclusion in embedded training. However, extenuating circumstances may justify their inclusion for ET. Embedded training is now recognized as a viable alternative for consideration when degradation in skill proficiency is likely due to infrequent application or where constant practice is needed to maintain performance proficiency.

- Criticality
- Perishability
- Consequences of Improper Performance
- Hands-on Training Needed?
- Delay Factor
- Complexity of Task
- Safety Factors
- Fidelity Requirements

Figure 2. Embedded Training Task Selection Factors

ET was first successfully employed in the 50s with the development of the Semi Automatic Ground Environment (SAGE) System for the U.S. Air Force. While this embedded training application was successful, there was little movement to consider incorporation ET into other systems (3:515).

During the 60s, embedded training was used for the Pershing missile systems, T1 Simulator for the Nike Hercules, the AN/TPQ-21 Basic Hawk Missile System, the Automated Programmed Instruction (API) and Astronaut training for NASA. During the 70s, ET was used for the upgrade of the Basic Hawk Missile System to the AN/TPQ-29 Improved Hawk Missile System. The Programming Language for Interactive Teaching (PLANIT) was also tested and validated in ET applications for teaching non-system-tied military skills during the MASSTER 122 test and for teaching tactical data system skills using the Tactical Fire Direction System (TACFIRE).

During the 80s, the application of ET has increased. Embedded Training was the training concept for the Fiber-Optic Guided Missile (FOG-M), the Army's Howitzer Improvement Program (HIP), and the SGT York. The Navy used ET on the Language Translator (L-TRAN) for the Naval Tactical Data System (NTDS), and AN/SPA-25G Radar Repeater, the On-Board Maintenance Trainer (OBMT) and the AEGIS Combat Training System (ACTS) to name a few. Also, the Air Force's On-Board Simulation (OBS) for the F-15, On-Board Electronic Warfare Simulator (OBEWS) and Pilot training uses ET.

Some of the ET programs currently under development for the Army are the following: Guard Unit Armory Device (GUARD) Full-Crew Interactive Simulator Trainer (FIST) - Armor (GUARDFIST-I), Light Helicopter (LHX) Family, Advanced Antitank Weapon System - Medium (AAWS-M), Multiple Integrated Laser Engagement System (MILES) - Air to Air Stinger (ATAS)(MILES-ATAS), the Armored Family of Vehicle (AFV) Program, and the Forward Area Air Defense System (FAADS). The Air Force is developing the use of ET for Aircraft cockpit training, High Speed Flyouts, and Reconnaissance Attack Fighter Training System (RAFTS) a T-38 replacement.

Army doctrine requires that identification of the training device needs to occur early-on during the formulation of the Required Operational Capability (ROC). During the development of the ROC, ET is considered and must be identified as a requirement, if applicable, in the operational characteristics and training assessment paragraphs. Identifying the requirement for ET as an essential characteristic of the system causes ET to be developed as part of the operational system. ET issues must be considered early enough to be incorporated into initial prototype designs. ET capabilities to train individual tasks through force-level collective tasks has been described in AR 350-38. Embedded training is described as encompassing four training categories:

(1) Category A - Individual/operator training objective: To attain and sustain individual, maintenance and system orientation skills.

(2) Category B - Crew training objective: To sustain combat ready crews/teams. This category builds upon skills acquired from

Category A.

(3) Category C - Functional training objective: To train or sustain commanders, staffs, and crews/teams within each functional area to be utilized in their operational role.

(4) Category D - Force Level (Combined Arms Command and Battle Staff) training objective: To train or sustain combat ready commanders and battle staffs utilizing the operational system in its combat operational role.

The determination of appropriate category application for a given type of system/training strategy has not been established, nor have any heuristics for applying ET to meet the objectives of a given category been documented. Training developed follows AR 350-38, Training: Training Device Policies and Management, as a guide to define the term Embedded Training (ET). Through a thorough analysis using ARI 80-25 "How to Determine Training Device Requirements" and the new ARI ten volume Series: Implementing Embedded Training, the training developer determines the training need and requirements. In conjunction with this effort a methodology to determine the stimulus requirements and levels of fidelity needed for effective training is sometimes conducted based upon The Army Evaluation Group (TAEG) and contained in Reports No. 16 and No. 23, Focus on the Trained Man. These efforts are tailored to the process of specifying ET characteristics to achieve the most effective instructional delivery system.

Generally ET progresses through three major analysis stages. These stages are illustrated in Figure 3. During initial concept analysis an examination of the hardware and software constraints of the actual system must be conducted. Additionally tasks and human performance requirements for the system must be investigated. During the second phase, the information gathered during concept analysis is used to develop conditions and standards for task performance, task practice requirements, and to establish training priorities for ET. During the third phase of ET analysis the ET training component of the system is defined, and the detailed ET design is developed. This entire process is interative and must be adjusted to changes made in the developing system. Often the real system is limited in its capacity to handle the entire ET requirements. The ET component design must be maximized within the limits of the system.

Once the system design and the ET design are known and are relatively stable, development of the ET component must begin. This process is summarized in Figure 4. The elements illustrated this figure reflect the types of actions more typically associated with ISD. These actions can only occur when a detailed ET design exists defining the curriculum, the software and computer resources available, defining the interface with the operational system, and

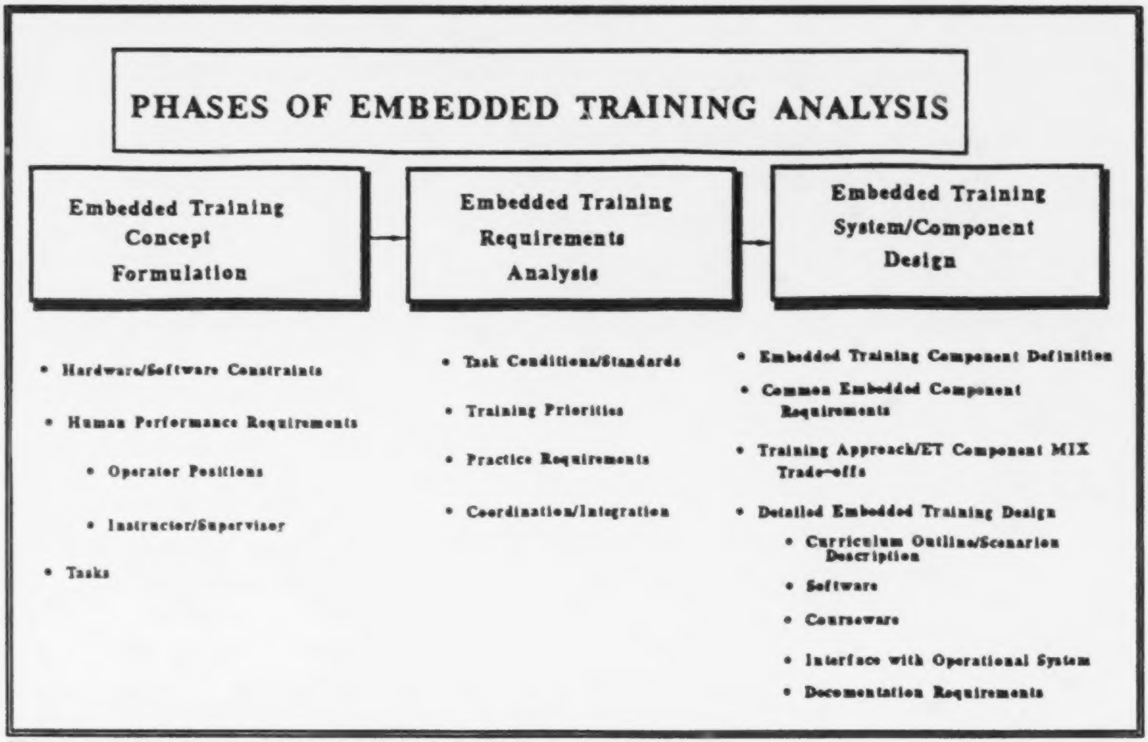
PHASES OF EMBEDDED TRAINING ANALYSIS
Embedded Training Concept Formulation
Embedded Training Requirements Analysis
Embedded Training System/Component Design
• Hardware/Software Constraints
• Human Performance Requirements
• Operator Positions
• Instructor/Supervisor
• Tasks
• Task Conditions/Standards
• Training Priorities
• Practice Requirements
• Coordination/Integration
• Embedded Training Component Definition
• Common Embedded Component Requirements
• Training Approach/ET Component MIX Trade-offs
• Detailed Embedded Training Design
• Curriculum Outline/Scenarios Description
• Software
• Courseware
• Interface with Operational System
• Documentation Requirements

Figure 3 Phases of Embedded Training Analysis

defining the documentation requirements. A critical concern is the way the ET courseware will be activated and deactivated and the relationship between the ET and the system.

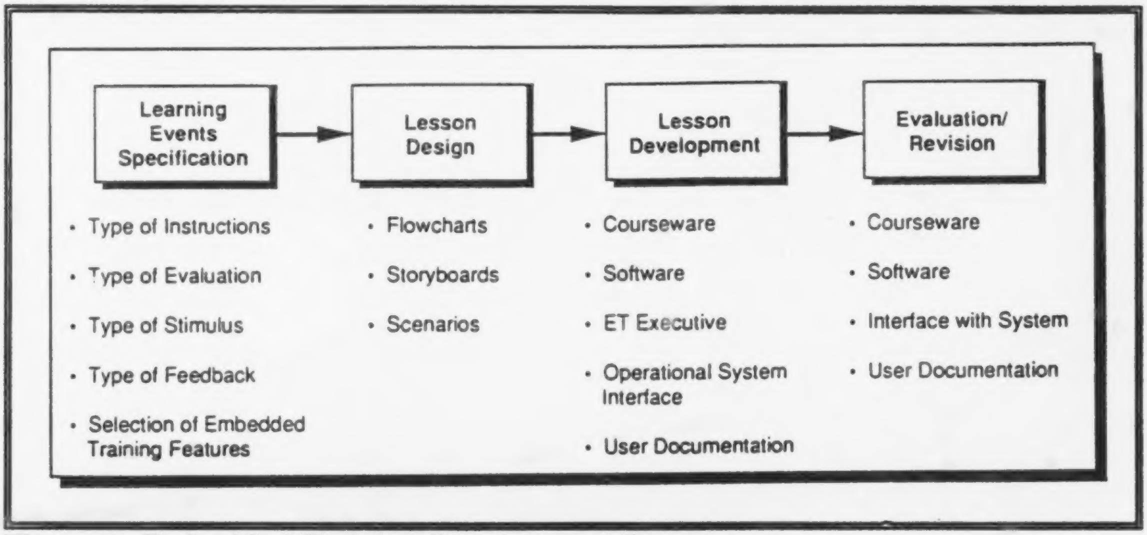
Learning Events Specification
Lesson Design
Lesson Development
Evaluation/ Revision
• Type of Instructions
• Type of Evaluation
• Type of Stimulus
• Type of Feedback
• Selection of Embedded Training Features
• Flowcharts
• Storyboards
• Scenarios
• Courseware
• Software
• ET Executive
• Operational System Interface
• User Documentation
• Courseware
• Software
• Interface with System
• User Documentation

Figure 4. Embedded Training Development Process

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Non-military use of embedded training appears to be increasing. Five of the most noteworthy commercial applications are: the Rochester Gas and Electric Company, the New Hampshire Yankee, the Arizona Nuclear Power Project, the Ford Motor Company, and Martin Marietta Electronics Systems Company (ESC),

The Rochester Gas and Electric Company has established plant-specific training as a portion of the licensed operator training program for the Robert E. Ginna Nuclear Station. The simulator is functionally identical to the operational system but is maintained separately due to the unique safety concerns of the nuclear industry. The primary training subsystems involve stimulation of the Safety Assessment System (SAS) and the Plant Process Computer System (PPCS). The trainer simulates the SAS and the PPCS functions for all modes of operation including hot and cold startup, cold shutdown, prestart checks, preheating, power maneuvering, and normal, abnormal, and emergency operating conditions.

Both the New Hampshire Yankee which runs the Seabrook Station Nuclear Power Station in Seabrook, New Hampshire, and the Arizona Nuclear Power Project in Wintersberg, Arizona, have developed and adopted site-specific, computer-based simulation to train plant operators to handle every conceivable situation they might encounter in the real reactor. The simulator is used as one training device supporting a systematic program of training and licensing operators in the safe and efficient operation of a nuclear power station and provides periodic refresher training and recertification, as determined by the Nuclear Regulatory Commission (NRC) licensing requirements.

Ford Motor Company hired Applied Science Associates (ASA) to develop the Automated Assembly Line Trainer (AALT). The AALT is designed to provide diagnostics and instruction in using, maintaining, troubleshooting, and repairing the automated assembly line. The system uses Interactive Videodisc (IVD) technology to deliver training and job/decision-aid data. The AALT can stimulate any system component and can be readily tailored to any part on the assembly line.

Martin Marietta ESC has developed and implemented an Aerospace Planning, Execution, and Control System (APECS). APECS is a large-scale computer integrated manufacturing effort for a highly sophisticated electro-optical system. The system is manufacturing LANTIRN electro-optical night vision systems. APECS consists of four major subsystems: 1) a material resource planning and control system; 2) a manufacturing engineering system capable of generating and maintaining manufacturing bills of material, routing, standards, and process plans; 3) shop floor control of work priorities, shop operations control, and labor data collection, and; 4) a system that satisfies strict military standards for performance and work measurement. The facility is automated, paperless, integrated, interactive, and computerized. It has been nicknamed the "paperless factory". The system allows the operator to call up detailed sketches, photographs, even video, showing the work to be performed. The Manufacturing Integrated Production Planning System (MIPPS) can create text, tools, sketches, and anything else the planner requires. The system has a training data base that is used for this to ensure that the real-time control of the shop floor are the keys to the paperless factory of the future.

The use of the operational equipment to assist in the training of employees appears to be growing both in military and commercial applications. Embedded Training trains an individual on the operational equipment and is training effective. The problem of the transfer of training from the training system to the actual equipment is not an issue.

ET is not the end all to training problems. It is, however, another media method available to properly train individuals.
Based upon this, the use of embedded training in nonmilitary settings must be analyzed in the media selection process to ensure that the most appropriate method is utilized. Some future commercial applications of embedded training are the water works industry, assembly line companies, vocational education, shop training, user friendly computer training-- word processing, spreadsheets, databases, etc., school systems, communication systems and airline cockpit training to name a few.

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3. The Role of ET in the Training System Concept
4. Identifying ET Requirements
5. Designing the ET Component
6. Integrating ET with the Prime System
7. ET Test and Evaluation
8. Incorporating ET into Unit Training
9. Logistics Implications
10. Integrating ET into Acquisition Documentation

Title:

Metaphor and Instruction

Author:

Steven D. Tripp

Metaphor and Instruction

Instruction is, at least in part, concerned with assuring that students gain knowledge. The canonical case of knowledge acquisition is science. Scientists, faced with a confusing universe, attempt to order that confusion with propositions which explain and sometimes predict. Where do such propositions come from? In recent years, writers such as Bohm and Peat (1987) have suggested that metaphor lies at the heart of scientific insight. They write that, "The essential point...is that metaphors can have an extraordinary power, not only to extend the thought processes of science, but to penetrate into as yet unknown domains of reality, which are in some sense implicit in the metaphor" (p. 41).

Historical background

What is a metaphor? How do metaphors differ from similes, analogies, and models? These are not new questions but they have not been completely answered even today. The study of metaphor dates back to the ancient Greeks. Aristotle made the well-known distinction between similes and metaphors. According to Aristotle (1958), "Metaphor consists in giving [a] thing a name that belongs to something else..." (p. 368), while a simile is a comparison between two things using the words like or as. Analogies, according to Aristotle, are an explicit mapping of one relationship onto another. Models, a relatively new form of expression, are concrete and valid representations of the structure of a device or system (Mayer, 1989). Metaphors, similes, analogies and models all share some qualities; they all evoke some kind of comparison; they all use one thing to shed light on another; and they all rely ultimately on language. Metaphors differ from similes, analogies, and models in some ways, however. First, in using one name for another, as Aristotle would put it, one comes to see one thing in terms of another. Thus, users of graphic computer interfaces who put "files" in "folders" may come to actually believe that the files are in folders. Another aspect of metaphors is that ground of the comparison may be difficult to make explicit. The metaphor "Chevrolet is the heartbeat of America", although readily understandable, is not readily explicable. Additionally, metaphors must relate things that are not overtly similar. One can say that Math 101 at the University of Kansas is like (or analogous to) Math 1 at some other university, but one cannot say Math 101 is a metaphor for Math 1. The final point to be made about metaphors is that they often have a certain affective power that is usually missing from similes, analogies, and models. Consider "Chevrolet is like the heartbeat of America." Most people would agree that it is weaker than the metaphor.

As was mentioned above Aristotle was one of the first to discuss metaphor. There are two points to be made about Aristotle's treatment of metaphor. The first is that metaphor is seen as a figure of speech, not a cognitive phenomenon. The second is that, for Aristotle, metaphor still had an important function. In the Rhetoric (1958) Aristotle asserts that "We learn above all from metaphor" (p. 89) and that for the poet "the greatest thing by far is to have a command of metaphor" (p. 87). This point is noteworthy because not all thinkers believe metaphor is important. The Aristotelian position yielded to the pressure of empiricism and logical positivism (Johnson, 1980), and was largely discounted through the mid-1960's.

The alternate position, attributable to Plato, is that metaphor is essentially a frill or deception. This view interprets metaphor as a rhetorical device and therefore an imprecise and often misleading tool (Hoffman & Honeck, 1980; Johnson, 1980). This position is typified in John Locke's (1961) opposition to figurative language on the grounds that:

> if we would speak of Things as they are, we must allow that all the Art of Rhetorick, besides Order and Clearness; all the artificial and figurative application of Words Eloquence hath invented, are for nothing else but to insinuate wrong Ideas, move the Passions, and thereby mislead the Judgment; and so indeed are perfect cheat: And therefore, however laudable or allowable Oratory may render them in Harangues and popular Addresses, they are certainly, in all Discourses that pretend to inform or instruct, wholly to be avoided; and where Truth and Knowledge are concerned, cannot but be a great fault, either of the Language or Person that makes use of them. (pp. 507-8)

Modern views

The modern study of metaphor can be traced to the work of I. A. Richards (1936). Richards felt that verbal metaphor was a product of a more basic psychological mechanism, rather than just being a figure of speech. Richards contributed the terminology (e.g. tenor, vehicle, and ground) which remains in use today in much research, although often in a different sense from Richards' usage. In a metaphor such as, "Man is a wolf." , man is the tenor (or topic as most modern writers prefer), wolf is the vehicle, and the idea that the men share some qualities with wolves is the ground of the metaphor.

Max Black held a similar view of metaphor to Richards. However, Max Black (1979) expanded Richards' position and held that every metaphor mediates a structural correspondence between a primary subject and a secondary subject which are to be regarded as systems of belief rather than as things. The metaphor results in an interaction between the primary and secondary subject which creates a new understanding of both.

Following upon the work of Richards and Black, Lakoff and Johnson (1980) demonstrated convincingly that ordinary language is systematically riddled with metaphor: "We use ontological metaphors to comprehend events, actions, activities, and states" (p. 30); and ". . . we typically conceptualize the nonphysical in terms of the physical . . ." (p. 59). The importance of this book was that it demolished the notion that metaphor is some kind of special language, limited to literary applications. It became obvious that not only is metaphor more than a figure of speech, but it is also a ubiquitous feature of human communication.

Given that metaphors have psychological importance it is not surprising that some felt they may also have educational importance. Ortony (1975) cited three reasons why metaphors should be helpful in education: they are vivid, they express the inexpressible, and they are informationally compact. The vividness hypothesis holds that metaphor presents information in a particularly concrete manner, thereby aiding retention. The inexpressibility hypothesis holds that some ideas which cannot be expressed literally can be expressed metaphorically. The compactness hypothesis holds that metaphors "chunk" information, increasing communicational efficiency.

A related part of Ortony's thesis is that metaphor allows a transfer of meaning from something well-known to something less well-known. Theorists such as Haynes (1975), Johnson (1980), and Petrie (1979) support this notion while further suggesting that the transfer of structures from one domain to another may involve the creation of

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new cognitive structures. Black (1979) noted that, "... every metaphor may be said to mediate an analogy or structural correspondence" (p. 31), a position which supports the notion that metaphor mediates the transfer of knowledge from one domain to another. Whether or not this transfer of knowledge involves the creation of something new depends on the interactionist versus substitutionist point of view taken.

Theories of Metaphor

According to the substitution view, a metaphor is simply an elaborate way of stating something that could be stated literally. As a result a metaphor is viewed as no different from a simile or an analogy except that it is typically more abbreviated. To assert that, "Man is a wolf" is only an alternate, indirect way to suggest that man is vicious or predatory. The word "wolf" substitutes for the attributes vicious or predatory. Waggoner (1984) suggested that nearly all metaphor theorists are substitutionists, whether they identify themselves as such or not.

The interaction view of metaphor suggests that metaphor is more than a similarity which could be expressed by literal language (Richards, 1936; Black, 1962, 1978, 1979). Interactionists claim that metaphor actually creates a similarity that did not previously exist (Black, 1979). Although some psychologists have embraced interactionist views of metaphor (e.g., Tourangeau & Sternberg, 1981; Verbrugge, 1980), Waggoner (1984) has argued that in operationalizing their theories they more closely resemble substitutionists.

For educational purposes the substitution theory, in a strict sense, suggests that metaphor plays only a limited role (Green, 1979). Substitutionists assert that a metaphor only points out a similarity which could be expressed in other, more literal, words. If true, it would seem reasonable to simply present instructional information in literal form. However, because the distinction between substitution theory and interaction theory is not always maintained, even substitution theorists have advocated the educational benefits of metaphor (Ortony, 1975). Despite the growing respectability of metaphor as a cognitive phenomenon, the educational view of metaphor has been primarily Platonic: To teach metaphor as a literary device has been acceptable but to use metaphor as an educational tool has been equated with deception (Petrie, 1979) and has been described as unnecessary (Green, 1979; Miller, 1976).

Science and metaphor

The literal bias of educational empiricism has not always prevailed in the field of science. One person who implicitly recognized the value of metaphor was Leonardo Da Vinci. Winternitz (1967) described Da Vinci's obsession with metaphor and how it led to several inventions. In one instance, Leonardo compared the spine with its cords and muscles to the mast of a ship and recommended, as a pedagogical device, the replacing of muscles in models of the spine with thin cords to represent the lines of force. Thus Da Vinci demonstrated his understanding of the instructional value of the non-literal representation of a domain of knowledge.

During the 1960's, investigators began to recognize the apparent importance of non-literal imagery to the explanatory aspects of scientific theory. For example, Hempel (1965) showed that some theoretical terms cannot be reduced to literal observational statements. Thus the naive idea that science was based on the literal interpretation of data was weakened. Black (1962) and Hesse (1966) refined the relationship between

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scientific theories, models which instantiate those theories, and the metaphors which express the relationship between theories and models.

Miller (1984) described the 19th century German scientific tradition in which Einstein was educated: "The matrix of science, philosophy, and technology in which Einstein was educated and worked placed a high premium on visual thinking, a mode of thought that he preferred for creative scientific thinking" (p. 48). Einstein's earlier education included attending a Pestalozzian school. Central to Pestalozzi's educational philosophy was the concept of Anshauung which referred to a customary intuition or image (Walsh, 1952). For example, in the famous 19th century discussions of the lines of electromagnetic force, ". . . Anshauung refers to the intuition through pictures formed in the mind's eye from previous visualizations of physical processes in the world of perceptions; Anshauung is superior to viewing merely with senses" (Miller, 1984, p. 110). For Pestalozzi the meaning of Anshauung varied from perceptions of the senses to the form imposed on reality by the mind. Educationally, this meant that perceptions should always precede words in education. Einstein went from this Pestalozzian environment into the 19th century German scientific community, where, coincidentally, Anshauung was also a central concept. Though Anshauung is generally considered to be untranslatable but from the previous quotation it is apparent that metaphoric image would approximate the meaning.

The importance of metaphorical imaging cannot be underestimated. One of Einstein's famous Gedanken experiments, which led to the theory of relativity, consisted of imagining himself traveling alongside a light wave. This is a clear metaphoric image, formed completely within the tradition of Anshauung, which allowed a radically new interpretation of reality. Nor was this an isolated case, as Einstein used similar images to arrive at other conclusions, such as the gravitational bending of light.

Empirical studies

There are two areas of psychological study concerned with metaphor comprehension. The first attempts to elucidate developmental questions. The second deals with metaphor processing by mature subjects.

A sizable body of research on the developmental aspects of metaphor comprehension and production was reviewed by Ortony, Reynolds, and Arter (1978). Its relevance to instruction should be obvious. If metaphors are not understood, or understood with difficulty, by children then their instructional utility will be minimal. Ortony et al. found that the early developmental studies were plagued with the usual difficulties in research on children. For some studies like Billow (1975) and Winner, Rosenthiel and Gardner (1976) the stimulus materials were criticized for being obscure or atypical. In general, however, the studies showed that children have some ability to comprehend metaphor although it increases with age. Evidence of metaphor production was obtained for children as young as five years old (Billow, 1975) and for some tasks, at least, children's performance was as good as that of adults (Gentner, 1977). In more recent research, Winner, McCarthy, and Gardner (1980) also found strong evidence of use of metaphor in young children and found sequential steps in metaphor development, with production of action-based metaphors preceding the production of perception-based metaphors. Pollio and Pickens (1980) found a similar developmental pattern; recognition first followed by paraphrase and then explication. However, Waggoner, Messe and Palermo (1985) reported that children as young as 7 years of age correctly interpret metaphors when embedded in story schemata, suggesting that young children's inability comprehend metaphors may be experimental artifacts due to

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contextual problems. Recent reviews of the literature have concluded that, although metaphoric comprehension may be confounded by various contextual, linguistic, and developmental factors (Vosniadou, 1987), children as early as the pre-school years have the competence to understand metaphors (Winner, 1988).

A second type of research has focused on the time needed to process metaphor under various conditions. The goal of these studies has been to determine whether or not metaphors are more difficult to process than literal language. The hypothesis is that the apparently anomalous nature of metaphorical language should require additional processing and therefore reaction times should be slower. Two-process theories derive from Kintsch (1974). On the other hand, if metaphor is not anomalous, comprehension time should be approximately the same as literal language.

In general metaphor has not been found to increase processing time. Ortony (1980) reported that processing time interacts with context: Where sufficient context exists, metaphors are comprehended as rapidly as literals. Inhoff, Lima, and Carroll(1984) supported this position noting that, ". . . even in circumstances in which few schemata have been activated by the time the target sentence is read, metaphors can be comprehended about as easily as literals" (p. 564).

Harris, Lahey, and Marsalek (1980) reported that metaphors can be processed effectively even under heavy attentional disadvantages. Using an incidental-learning paradigm, subjects were asked to listen to sentences containing metaphors, dead metaphors, and literal statements. A distracting task (counting the words in each sentence) was embedded between sentences. On a forced-choice recognition test, nonmetaphors were recognized significantly less often than metaphors and dead metaphors. Thus research suggests that, for adults, metaphorical language is no more difficult to comprehend and recognize than literal language. In fact, Hoffman and Kemper (1987) have argued that the reaction time studies cannot resolve the two-process question, but that most of the evidence supports that idea that there is no special metaphor comprehension process.

The memorability of metaphorical language has also been studied. Harris, Lahey, and Marsalek (1980) reported that metaphors are sometimes easier to remember than literal statements. Reynolds and Schwartz (1983) reported greater memorability for metaphorically stated conclusions rather than literally worded ones. Thus, in certain instances metaphors appear to be easier to remember than literal sentences.

In conclusion, studies have indicated that young children have metaphoric competence, although this may be interfered with by a variety of factors. In adults, there is no evidence that metaphors are more difficult to comprehend than literal language and there is evidence that, under some conditions, metaphors are more memorable than literal statements.

Instructional uses of metaphor

Instruction is a special case of communication where the potential of metaphor appears formidable. Norman, Gentner, and Stevens (1976) noted that:

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> One important component of the process of learning and teaching is that of communication. The teacher has the task of conveying a particular knowledge structure to the student. The learner has the task of deducing just what structure is intended by the teacher, as well as the additional task of adding the new information to his previous knowledge in such a way that it can be referred to and used at a later time. Many of the problems of learning and teaching can be understood as problems in this communication process. (pp. 186-7)

Problems in the communication process may be traced to problems in the medium or problems in the encoding and decoding process. For example, Bonar and Soloway (1985) have shown that many computer programming errors may be traced to the inaccurate mapping of novice natural language knowledge onto a programming language. Students mistakenly overextend the metaphor of language (as in computer language) and make numerous unwarranted assumptions. This indicates the tendency of students to supply their own metaphors when none are explicitly provided by the teacher. Carroll and Thomas (1982) argued that the application of metaphors to new knowledge domains by students is inevitable and that not all metaphors are equally efficacious, therefore appropriate choice of metaphors is crucial.

The casual use of metaphor by teachers is probably more common than often assumed. However, little research has been reported to validate the use. In one study, Wilson, Gaff, Dienst, Wood and Barry (1975) found that an important characteristic of influential teachers is the frequent use of analogies. For the most part, systematic attempts to use metaphor pedagogically are rare.

There are at least three way in which metaphor can be used to influence instruction. The first is the teacher's (or instructional designer's) conception of the educational process and his/her role in that process. The second is the student's conceptual of his/her role. The third is in the mediation of the content itself.

Numerous writers have commented on the fact that the metaphors we adopt for instruction can influence how we function as teachers or instructional designers (Egan, 1989; Heitland, 1981; Kloss, 1987; Marshall, 1988; Moore 1987; Munby, 1986; Tom, 1984). A particular case of this can be found in the "container and conduit" metaphor of mind and language (Lakoff and Johnson, 1980; Mosenthal, 1987; Reddy 1979). If we think of language as "containing" meaning which it "transmits" to a "data storage device" like long- or short-term memory our lessons will assume certain characteristics. On the other hand, if we think of brain faculties as muscles to be exercised and strengthened thereby, our instructional approaches will assume other forms. Some metaphors may be adopted unthinkingly, based upon the general intellectual assumptions of our time. Others may be adopted deliberately. In any case it seem obvious that if we think of ourselves as "delivering" instruction, or coaching, or acting as facilitators, or serving as travel agents, our instructional strategies will bear the stamp of our metaphors.

The second way in which metaphors can influence instruction is in forming the student's unconscious or meta-cognitive conception of his or her role in the instructional process. One program which makes deliberate use of metaphor is Gordon's Synectics (1961, 1971) which treats metaphor as a metacognitive strategy and trains students in this strategy. The Synectics curriculum involves training in personal analogy, direct analogy, and compressed conflict. Personal analogy connects mentally oneself to the device or mechanism under study and imagining the results. Direct analogy is the borrowing of natural solutions for engineering problems. The idea of caissons, for example, came directly from the observation of shipworms. Finally, compressed conflict derives from the deliberate juxtaposition of incompatibles, such as burning ice, in order to force the thinker to go beyond the assumed domain of the problem. Sanders and Sanders' (1984) course in teaching creativity through metaphor is derivative from Gordon's Synectics. The Synectics curriculum has not been subject to rigorous evaluation.

A more controlled set of studies was performed by Paris and his colleagues (reported in Paris, Wixson, and Palincsar, 1986). Paris et al. used metaphors to teach reading strategies. Metaphors such as "reading detectives" and "planning reading trips" were used to concretely structure metacognitive strategies. In addition to supporting reading skills, these metaphors stimulated group discussions about reading and thinking. Students exposed to this metaphorical curriculum exhibited significant improvements in reading awareness and use of reading strategies.

The third way in which metaphors can be used is to mediate content itself. If metaphors express the inexpressible, are more vivid or, chunk information they should have positive effects on comprehension and memory. Pearson, Raphael, TePaske, and Heyser (1981) found that metaphoric sentences were recalled better than literals when placed in unfamiliar passages, although overall recall was unaffected. Reynolds and Schwartz (1983), as reported above, obtained contrary results. They found that metaphors placed at the end of prose passages were recalled better than literal counterparts and that overall recall was also improved. Reynolds and Schwartz's metaphors served as summarizers which may explain their better overall results. Hayes and Mateja (1981) found that metaphors embedded in text produce greater engagement than comparative organizers. Subjects who read a passage with embedded metaphoric allusions produced more inferences and less incorrect information than subjects given a comparative organizer first. Because this same result was found with entirely different materials in an earlier study (Hayes & Tierney, 1980) they argued that the effect is reliable. In spite of these results, Becker and Carrier (1985) and Yarbrough and Gagné (1987) found that the insertion of multiple metaphors into a text did not increase learning. Both of these studies used unrelated metaphors and thus do not speak the effect of a single systematic metaphor used to structure a body of content.

There is not a body of literature indicating that metaphors, used haphazardly, will increase learning. However, metaphors used systematically do have positive effects on learning and retention of content.

Theoretical integration

General guidelines for the use of metaphors have been reported elsewhere (Carroll and Thomas, 1982), but there is also the possibility of theoretical integration of metaphors into instructional design theory, Reigeluth's elaboration theory (Reigeluth and Stein, 1983) and Keller's motivational theory (Keller, 1983) both include metaphors (as a kind of analogy) into their prescriptions. Both authors seem to regard metaphors as adjunct aids to instruction rather than having a central function.

An alternative view is to see the use of metaphor as a function of the degree of abstractness of the canonical case of the content being taught. Reigeluth calls this canonical case an epitome and this serves as a base for his elaboration theory. For Reigeluth an epitome consists of a small number of ideas that are most basic or fundamental to the particular type of content. In the case of a conceptually based biology course an example of an epitome would be the animal phyla. For a theoretical course such as economics, the principle of supply and demand would be an epitome. Reigeluth gives no example of an epitome for a procedural course like statistics. The essential issue here is whether a literal epitome is the preferred treatment under all conditions. Since the comprehensibility of an example depends upon the degree to which its crucial characteristics are perceptually salient or not, it would seem that there must be cases in which the abstractness (or at least the unobservability) of the crucial features of the example would render it less tha useful. As a simple case consider learning to ski. The crucial characteristics of body movement are not necessarily external. A skilled skier must hold an inner model of correct posture, etc. A teacher of mine once described this ski posture as holding a basketball in your lap rather than pointing out the correct stance in literal terms, which an epitome would require. Similarly in the Paris studies above, children were told to think of themselves as detectives. Presenting good reading strategies in literal terms to children would require the comprehension of exceedingly abstract ideas. One can easily imagine that in statistics, economics, and biology, the degree to which a literal epitome would facilitate learning would depend upon the degree to which the students could assimilate abstraction from an example.

Thus, as a hypothesis, one could modify elaboration theory in this way. If the canonical case of the content is relatively concrete or salient to the student, then use an epitome to begin a course. On the other hand, if the canonical case is abstract or obscure, from the student's point of view, then use a metaphor to introduce the content.

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Title:

Applying Linquistic Analysis to Instructional Design

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Applying Linguistic Analysis to Instructional Design

The terminology of linguistic discourse is often applied to instructional design situations. We speak of tutorials and dialogues, interface languages and interactions. It is rare to see these terms taken literally, however. The discipline of linguistics has formal description techniques which may allow us to describe the structure of computer-based interaction with greater objectivity. Such devices have been applied to stories (Mandler and Johnson, 1977), the cinema (Carroll, 1980), computer interfaces (Reisner, 1981; Moran, 1981; Payne and Green, 1986) and classroom discourse (Mehan, 1979). The application of such formal devices to instructional systems design is a logical extension of such a trend.

This paper is a short tutorial in formal grammar with speculative examples of how it could be used as a research tool for task-analysis, the description of lesson structure, the modeling of interactive dialogue, and perhaps the instructional design process.

As an example of the application of linguistic techniques to ISD, consider Gagné's well-known "events of instruction." It is hard to evaluate the theoretical status of the events. How could they be empirically tested? Are all events necessary always? How are they to be related to course-level events, units, lessons, and sub-lessons? Must they be applied in a fixed order? If not, to what extent can the order be transformed?

One way of thinking about these problems is to analogize. The events of instruction may be compared to the parts of speech. Sentences are made up of parts just as lessons are. Sentences are infinite in variety but they are constrained structurally. In other words, certain strings of words are considered to be well-formed while others are not. The description of these constraints is a goal of linguistics. Instructional designs may be thought of as sentences made up from events. Some combinations of events may be thought of as well-formed strings while others may violate our intuitions of well-formedness. A grammar of instructional design would assign descriptions to lesson materials. A basis for assigning descriptions to the structure of instruction may be thought of as a theoretical goal of instructional design research.

Formal Grammar

At the mention of the word "grammar," some people remember tedious sentence diagramming exercises performed under the scrutiny of a schoolmarm. Others recall laboring to memorize Latin verb conjugations and noun declensions. Those who write professionally think of the handbooks they consult to ensure the propriety of their usage. To the linguist however, grammar is not an artifact of language study nor an arbitrator of style. Rather, the linguist views grammars as tools to describe the complex cognitive system which language is.

The use of the plural "grammars" is deliberate: to the linguist grammar is not the monolith that it is to man in the street. Linguists ardently debate the relative merits of a number of grammars, such as Case grammar, Tagmemic grammar, Transformational-Generative grammar and Traditional (Latinate) grammar, to name a few. Power and parsimony are the chief criteria considered in attempts to empirically determine which system is superior.

The concern with parsimony leads to the formal, that is, symbolic, property of modern grammars. The ideal of power requires that a finite set of rules account for the infinite number of possible sentences which any language has. One such grammar is Phrase Structure (PS) grammar, which is an algebraic system using symbols to represent variables. It has rules which specify whether a given string of words belongs to the set of valid English sentences. Moreover, it has rules which break down ("rewrite" in the linguistic terminology) sentences into their constituents. Figure 1 is a simple PS grammar of English.

Story Grammar

One of the first and best-known applications of formal grammar outside of pure sentential syntax was Mandler and Johnson's (1977) paper on story grammar. Essentially, Mandler and Johnson asserted that traditional stories (fairy tales, legends, etc.) have a structure which can be represented formally. The importance of this claim rests on the assumption, borrowed from linguistics, that such structures are "psychologically real." That is, such grammars are representations of knowledge that experienced story-readers hold in their heads. Mandler and Johnson's grammar (Figure 2) consists of a finite set of primitives and a finite set of recursive rewrite rules which are capable of describing an indefinitely large number of stories.

S → NP + VP
NP → DET. + N + (S)
DET. → {the, a, this, that, etc.}
N → dog, window, neighborhood, hope, etc.

$$\text{VP} \rightarrow \begin{Bmatrix} \text{Vi + (PP)} \\ \text{Vt + (NP)} \\ \text{be + Adj} \end{Bmatrix}$$

Vi → walk, coughed, spoke, etc.
Vt → hit, cover, inform, etc.
be → am, are, is, was were, been, being
PP → Prep + NP
Prep → to, for, at, etc.
Adj → blue, tall, old, etc.

Figure 1. A simple phrase structure grammar of English

There is a need for a short explanation of notational conventions. Parentheses indicate optional items. Parentheses marked with a superscripted index n indicate that the item may occur one or more times. Brackets indicate mutually exclusive items. EVENT* indicates that one terminal event is conjoined with one or more other terminal events within a single higher-level node. STATE* has a similar meaning. Three types of connection are allowed: AND, THEN, and CAUSE. AND and THEN define temporal relations and CAUSE defines an explanatory relationship. These connections are rendered in lower case in the figure to improve readability.

FABLE → STORY and MORAL

STORY → SETTING and EVENT-STRUCTURE

$$\text{SETTING} \rightarrow \left\{ \begin{array}{l} \text{STATE* (and EVENT*)} \\ \text{EVENT*} \end{array} \right\}$$

STATE* → STATE ((and STATE)^{n})

$$\text{EVENT*} \rightarrow \text{EVENT ((} \left\{ \begin{array}{c} \text{and} \\ \text{then} \\ \text{cause} \end{array} \right\} \text{EVENT)}^{n}\text{) ((and STATE)}^{n}\text{)}$$

EVENT-STRUCTURE → EPISODE ((then EPISODE)^{n})

EPISODE → BEGINNING cause DEVELOPMENT cause ENDING

$$\text{BEGINNING} \rightarrow \left\{ \begin{array}{c} \text{EVENT*} \\ \text{EPISODE} \end{array} \right\}$$

$$\text{DEVELOPMENT} \rightarrow \left\{ \begin{array}{l} \text{SIMPLE-REACTION cause ACTION} \\ \text{COMPLEX-REACTION cause GOAL-PATH} \end{array} \right\}$$

SIMPLE-REACTION → INTERNAL-EVENT ((cause INTERNAL-EVENT)^{n})

ACTION → EVENT

COMPLEX-REACTION → SIMPLE-REACTION cause GOAL

GOAL → INTERNAL-STATE

$$\text{GOAL-PATH} \rightarrow \left\{ \begin{array}{l} \text{ATTEMPT cause OUTCOME} \\ \text{GOAL-PATH (cause GOAL-PATH)}^{n} \end{array} \right\}$$

ATTEMPT → EVENT*

$$\text{OUTCOME} \rightarrow \left\{ \begin{array}{c} \text{EVENT*} \\ \text{EPISODE} \end{array} \right\}$$

$$\text{ENDING} \rightarrow \left\{ \begin{array}{l} \text{EVENT* (and EMPHASIS)} \\ \text{EMPHASIS} \\ \text{EPISODE} \end{array} \right\}$$

EMPHASIS → STATE

Figure 2. Story Grammar

This story grammar can be used to define the structure of a traditional story (taken from Mandler and Johnson), such as that listed in figure 3.

1. It happened that a dog had got a piece of meat
2. and was carrying it home in his mouth.
3. Now on his way home he had to cross a plank lying across a stream.
4. As he crossed he looked down
5. and saw his own shadow reflected in the water beneath.
6. Thinking it was another dog with another piece of meat,
7. he made up his mind to have that also.
8. So he made a snap at the shadow,
9. but as he opened his mouth the piece of meat fell out,
10. dropped into the water,
11. and was never seen again.

Figure 3. Traditional Story

Figure 4 is a tree-structure (based upon Mandler and Johnson) which represents the traditional story with each phrase assigned a structural description. Each numbered node in the tree structure represents the corresponding phrase in the story. The circles with C's, A's, or T's in them represent CAUSE, AND, or THEN connections. As can be seen, this grammar is capable of defining the structure and therefore is empirically justified. If the grammar had not been capable of defining the story, it would have had to have been modified as a result of this empirical test.

Cinema Grammar

Carroll (1980) reports an attempt to write a grammar of the cinema. He builds his attempt upon the assumption, not that cinema is a language in the same sense as English, but rather on the methodological assumption that cinema has structure and that that structure may be elucidated using the formal techniques of linguistics. Figure 5 represents a portion of that grammar. The grammar as represented is not complete and is only presented to give a flavor of the type of analysis Carroll attempted. As can be seen, the grammar consists of a set of recursive rewrite rules which define the structure of scenes and events. The notation is similar to the previous grammars. The adequacy of this grammar is not crucial to our argument. It suffices to point out that grammars can be applied to objects which have temporal structure and relatively abstract primitives.

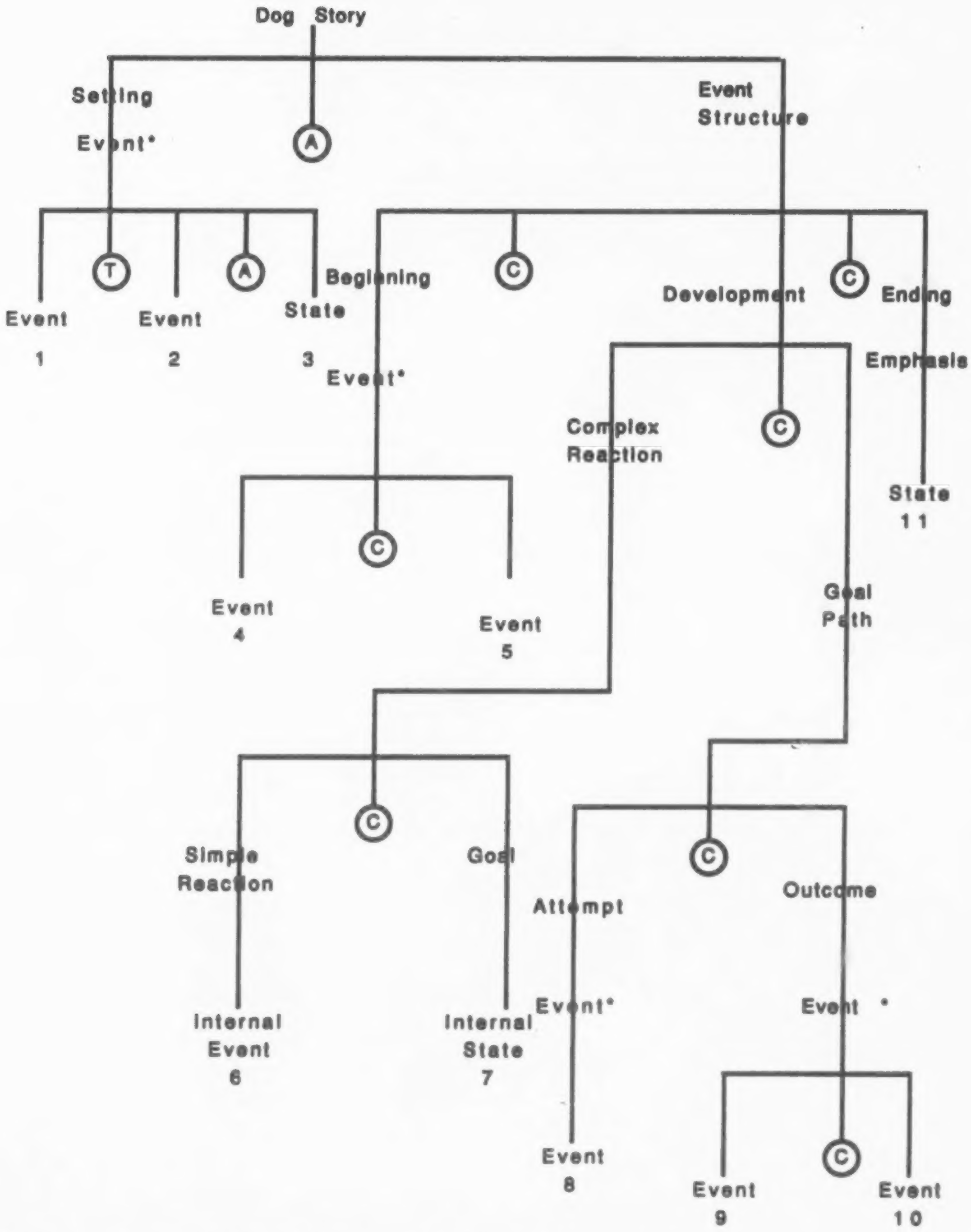
Dog Story
Setting
Event*
A
Event Structure
Event 1
T
Event 2
A
State 3
Beginning
Event*
C
Development
C
Ending
Emphasis
Complex Reaction
C
State 11
C
Event 4
Event 5
Goal Path
C
Simple Reaction
Goal
C
Attempt
Event*
Outcome
Event *
Internal Event 6
Internal State 7
Event 8
C
Event 9
Event 10

Figure 4. Tree-structure of the story in Figure 3

SCENE → LONGSHOT + DETAIL*
DETAIL → DETAIL + SCENE + DETAIL
EVENT → NOMINAL + SEQUENCE
SEQUENCE → ACTION*
ACTION → PREPARATORY-ACTION + FOCAL-ACTION
P → A*
F → A*

Figure 5. A cinema grammar

Computer Interface Grammar

Reisner (1981) first reported an attempt to apply formal grammar to a human factors design problem—the design of a command language for an interactive graphics program. Reisner pointed out that human factors design had tended to use behaviorist models for its methodology. Reisner argued that cognitive factors such as simplicity and consistency would be relevant to the design of "action languages" such as those used to control computer functions. Basically, Reisner argued that cognitive factors would influence the learnability of action languages and that these factors could be best modeled by a grammar. She wrote a grammar consisting of rewrite rules similar in notation to the examples from story and cinema grammar. Her grammar could also be expressed in tree diagrams after the fashion of the Backus-Naur Form used in computer science. Taking Reisner's ideas further, Moran (1981) gives an elaborate description of a command language grammar and elucidates how computer-based activities can be modeled grammatically at four levels of analysis from keyboard actions to intentions. Payne and Green (1986) take this approach one step further by developing a task-action grammar (TAG) which allows tasks to be mapped onto actions. The power of Payne and Green methodology is that cognitive structures (tasks) may be directly related to behaviors (keystrokes) while capturing such notions as simplicity and consistency. Payne and Green's hypothesis is that users can recognize action language consistencies across tasks and therefore can cognitively structure those tasks at a more abstract (i.e., simpler) level rendering the learning process easier. Thus a TAG makes predictions about the relative learnability of functionally comparable interfaces. These predictions are amenable to empirical testing. Such information is useful to the software designer, but it also could serve as a task analysis methodology for instructional designers who need to predict learning difficulties with computer interfaces.

Lesson Grammar

Mehan (1979) reported a description of the structure of actual lessons presented by a classroom teacher. Mehan asserted that the activities of the classroom seemed not to be under immediate stimulus control. It is well-known that actions under immediate stimulus control can be described by a finite state automaton (a Markov device), but behavior of a certain degree of complexity requires at least a context-free grammar. Mehan's work is important to the present paper in that it demonstrates the use of a formal grammar in an area closely allied to computer-based instruction. If lessons as complex as those delivered by an actual teacher can be effectively modeled with a grammar it would seem that lessons delivered under the controlled conditions of CBI could also be so described. Figure 6 presents a part of

Mehan's grammar. As can be seen, lessons consist basically of three parts. The main part, the Middle, consists of topically related sets. These sets are interaction sequences which consist of an initiation, a response, and an evaluation. An evaluation can be an interaction sequence itself, so the internal structure of these interactions can be arbitrarily complex. The implications of this grammar for the description of CBI are obvious. Can it fully describe existing CBI? This question is empirical and can only be satisfied by the actual description of existing materials.

Lesson → Opening-phase + Instructional-phase + Closing -phase
Opening, closing-phase → Directive + Informative/ Informative + Directive
Instructional-phase → Topically-related-set (=TRS) + (Topically-related-set)^n
TRS → Basic + Conditional-sequence (or Interactional-sequence)
Interactional-sequence → Initiation + Reply + Evaluation
Evaluation → Interactional-sequence

Figure 6. A lesson grammar

Events of Instruction

As an example of the application of linguistic techniques to ISD consider Gagné's well-known "events of instruction" as illustrated in figure 7. It is hard to evaluate the theoretical status of the events. How could they be empirically tested? Are all events always necessary? How are they to be related to course-level events, units, lessons, and sub-lessons? Must they be applied in a fixed order? If not, to what extent can the order be transformed?

1. Gaining attention
2. Informing learner of lesson objective
3. Stimulating recall of prior learning
4. Presenting stimuli with distinctive features
5. Guiding learning
6. Eliciting performance
7. Providing informative feedback
8. Assessing performance
9. Enhancing retention and learning transfer

Figure 7. The events of instruction

One way of thinking about these problems is to analogize. The events of instruction may be compared to the parts of speech. Sentences are made up of parts just as lessons are. Sentences are infinite in variety but they are constrained structurally. The description of these constraints is a goal of linguistics. Lessons may be thought of as sentences made up from primitive events. Primitive events may be grouped structurally under larger, more abstract events. Gagné's events are of the more abstract type since they do not specify actual lesson activities. An example of the transformation of the events of instruction into an instructional grammar applicable to CBI is given in figure 8.

Instructional-Unit → Beginning + Middle* + End
Beginning → GA(gaining attention) + IL(informing...) + SR(stimulating recall)
Middle* → Middle + (Middle)^n
Middle → PS(presenting...) + GL(guiding...) + EP(eliciting...) + PF(...feedback)
End → AP(assessing...) + EL(enhancing...)
GA→ bright color, loud sound, motion, etc.

Figure 8. A grammar of instruction

Note that this grammar makes empirical claims about the order of the events and their optionality or lack thereof. Since lessons often consist of more than one objective they may be arbitrarily complex. This grammars suggest how some of that complexity may be handled formally. No claim is made that this grammar is descriptively adequate. In fact, it surely is not. Lessons may consist of multiple instructional units. Several things may be presented before guiding and eliciting take place. This grammar does not capture these facts. However it does indicate the kinds of formal descriptions which can be accomplished. The advantage of such formalisms is that actual instructional designs may be checked against this grammar and validated for their "instructional grammaticality." Just as native speakers can recognize sentences that are not well-formed, experienced learners presumably can recognize lessons that are ill-formed. Empirical hypotheses about such lessons could be tested. Do learners learn less from "ungrammatical" lessons? Do learners slow down when presented with lesson events which violate their expectations of normality? These are a few of the questions which could be investigated with structural descriptions of the type provided by grammars.

A Grammar of Instruction Design

A common statement heard in ISD circles is that instructional design is "iterative." What this means is that designers iterate through a process of analysis, synthesis, and evaluation when producing instructional materials. That this model is not perfectly satisfactory is not news. Gagné and Briggs (1979) state that "This cyclical or iterative nature of the process is real, but its details cannot be shown accurately in advance, either by feed-forward or feedback loops in diagrams or by arrows connecting numbered stages in a list." (p. 20-21) One would expect that if the process truly is iterative, empirical evidence for that "reality" could be collected. On the other hand if design is not iterative, perhaps the cyclical metaphor is just the most powerful model that can be applied given the available descriptive language.

Alternative metaphors are available, though. There are those who have noted that design seems to be like a "conversation" with a problem situation (Schön, 1983). A conversation model of instructional design is not iterative. Just as conversations seem to develop opportunistically based upon speech acts and responses, designers in action seem to act alternatively on higher-level and lower-level problems, working on what seem to afford most chance of success at any given moment (Stauffer and Ullman, 1988). Linguists have attempted to characterize the structure of conversations through discourse analysis (e.g., Stubbs, 1981). The means by which discourse structures are represented is by grammars, much like in Mandler and Johnson and Mehan above. If the design process is indeed like a conversation then, contrary to Gagné and Briggs, its detail can be shown in advance, although its actual trajectory cannot be predicted. As an example of this possibility, the following design grammar is given. The minimal interactive unit of design is hypothesized to be the transaction which consists minimally of two events, an initiation and a response. Other types of events are feedback and interfaces. Interfaces are events which themselves initiate another transaction. Events consist of acts which are actual behaviors performed by instructional designers. Examples of acts are collecting needs data, doing task analysis, evaluating results, etc. A sample of such a grammar is given in Figure 9.

Design Session → (Transaction)^n

Transaction → I + R + (I/F) + (F)

I/F → Transaction

I → do needs analysis, do task analysis, ...

R → needs data, task representation, ...

I/F → evaluate results, ...

F → student behaviors, ...

Figure 9. A grammar of instructional design

The first thing to say about this grammar is that it is obviously inadequate. Design projects consist of more types of sessions and transactions than are represented. Some of those activities involve interactions with team members, reading research reports, attending conferences, removing constraints, etc. However, it does illustrate the kind of structural description which goes beyond simply saying that ISD is "cyclical." A cycle is a model of design. It may be the best that can be done if one restricts oneself to representing design with informal language. As is well-known though, science has generally been advanced by using formal devices. There is no reason why the science of the study of instructional design processes should handicap itself by restricting itself to informal language. In fact, a precedent for our argument can be found in Knowlton's classic 1966 article "On the definition of 'picture.'" Knowlton justified his attempt to develop a metalanguage for talking about pictures with a quote from Antoine Lavoisier.

> ...we cannot improve the language of any science without at the same time improving the science itself; neither can we, on the other hand, improve a science without improving the language or nomenclature which belongs to it (p. 157)

Summary

The ideas presented in this paper are far from complete. The possibilities of formal grammar as an instructional design device are unknown. At least it will facilitate the identification of testable hypotheses about optimal instructional sequences. Perhaps it will shed light on ISD from a theoretical standpoint but will have no practical application. Perhaps it can be modified to help designers generate lessons more fluently. Perhaps such grammar will allow the computer-generation indeterminately large numbers of different, acceptable lesson structures which can b fleshed out by subject matter experts. The automation of instructional design will require at the very least some formal theory of instruction. The most powerful formal theories known are grammars.

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Title:

Effectiveness and Efficiency of Elaboration Using CAI

Author:

Daniel T. Wilshire

Educators are no longer content to place all their emphasis on the environment and the materials being used by students to guarantee success. If a teacher wishes to present a new concept, concern is now being focused on how best to present that concept to the student.

The popularity of the personal computer in the schools and in training facilities has made the possibility of personal education a reality. It is now possible to diagnose educational weaknesses and to prescribe certain types of remediation by way of the microcomputer; this, in turn, frees the teacher to deal with other students in class while the one having difficulty with an educational concept is learning through his or her interaction with the computer.

The most recent development of interactive video has made the computer even more versatile by pairing it with visuals provided by video cassette recorders or by slide systems. The combination of visuals and computer-generated lessons has made an already confusing situation even more so; educators must now make many more decisions about the best way to present their materials to learners. One of these teacher decisions deals with the amount of and with the kind of elaboration needed to provide a desired degree of student achievement while maintaining a realistic time frame for the instructional process. This study deals with the question of elaboration and with the efficiency of instruction in an attempt to find the best way to present material to learners.

The major weakness in the human information processing system is the short-term memory. There are two reasons for this weakness. First, the information is only present in short-term memory for about ten seconds (Murdock, 1961) unless it is rehearsed. Second, the limited capacity of the short-term memory extends from five to nine units of information (Miller, 1956, Simon, 1974). In order to transfer information from short-term memory to long-term memory it must be coded. Coding is a transformation process in which new information is integrated in various ways with known information. Having information in long-term memory is of no use if it cannot be retrieved. The ability to remember or retrieve information from long-term memory often depends on establishing a good retrieval cue.

Recognizing the limitations of short-term memory and the need for providing good retrieval cues is a prerequisite for good instruction. Any strategy or manipulation taking place during instruction can alter the cognitive structure and strengthen the pathway to the information to be learned and remembered. Mayer (1980) reports that researchers have recently referred to this as the learning strategy hypothesis: "Mathemagenic activities aimed at making the learner actively integrate new information with existing knowledge affect the encoding, storage and eventual use of new material on performance tests" (p.770).

Many activities have been developed to help the learner integrate new information with existing knowledge, such as advance organizers, questioning strategies, feedback, and review procedures. Each of these activities provides for some degree of elaboration. Elaboration facilitates retrieval in two ways. First, it provides alternate retrieval pathways along which activation can spread (Anderson, 1976). Second, it provides extra information from which answers can be constructed (Reder, 1982). Although much research has been done with the above activities, questions still remain: (a) How much elaboration is needed to obtain the desired information? (b) Which mathemagenic activities provide the best means of gaining information? and (c) How much time should be spent on these activities to optimize information acquisition? This study added, in a step-like fashion, an increasing degree of elaboration to an instructional unit to determine what effect it would have on a posttest performance which would measure different levels of educational objectives. The activities which provided the elaboration were embedded questions, computer-generated feedback and overt rehearsal strategies.

The primary purpose of this investigation was to assess the effect of varying degrees of elaboration in a prose format using computer-assisted instruction with accompanying slides on post-test scores of college age learners.

By exploring elaboration strategies and their relationship with achievement, it was hypothesized that a significant contribution could be made to student achievement in terms of how people learn and how instruction could be organized so that retrieval of various types of knowledge might be facilitated.

This study was designed to test the following null hypotheses:

H1: There will be no differences in student achievement scores among the four elaboration formats (control, embedded questions (TR1), computer generated feedback (TR2), and computer generated feedback with a visual rehearsal strategy (TR3)) on tests measuring different educational objectives.

H2: There will be no interaction between prior knowledge levels and elaboration strategies among students in the four treatment groups.

H3: There will be no differences in lesson completion time between types of elaboration strategies among students on tests measuring different educational objectives.

H4: There will be no difference in efficiency scores on tests measuring different educational objectives by treatment group.

Elaboration

Lindsay and Norman (1972) have argued for the need to retain information longer in short-term memory to enable it to be processed further before entering long-term memory. Retrieving and interpreting correctly the information from long-term memory can be as much a problem as getting the information into long-term memory originally. Cues given upon retrieval direct a person to the information or assist him/her in generating new cues or imposing additional structure on the information. The more interconnections between information, the more likely it is that a retrieval cue will be effective; memory is strengthened in proportion to the redundant means utilized to retrieve information. Elaboration is the term used for the process by which additional paths or links to information are made. Elaboration uses connections to prior knowledge, imaging and inferences, and features from the current context to improve memory by increasing the interconnections and imposing organization on the information (Anderson, 1980, pp. 217-218). Therefore, the more extra processing one does that results in additional, related, or redundant propositions, the better one will remember the processed information. Elaboration provides redundancy in the memory structure. Redundancy can be viewed as a safeguard against forgetting and an aid to fast retrieval.

The learning strategy hypothesis states that mathemagenic activities aimed at making the learner actively integrate new information with existing knowledge affect the encoding, storage, and eventual use of new material on performance tests (Mayer, 1980). Elaboration techniques play an important role in the learning strategy hypothesis. In general, past work in this area has followed one of two paradigms: associative elaboration techniques using artificial verbal materials or integrative and comparative elaboration techniques using real world materials. The associative elaboration procedure involves making a visual and/or verbal association between the two stimuli. Comparative elaboration occurs when a learner actively explains the relation between two concepts in the text; integrative elaboration occurs when the learner explains the relation between a concept in the text and some concepts already in the learner's memory. These techniques differ from associative elaboration mainly in degree; they require more than a single mnemonic sentence or image.

In a study by Mayer (1980), the elaboration techniques were used to enhance learning of new technical information. His results provided consistent evidence that elaboration techniques can influence the outcome of learning, even when the material to be learned is in instructional text. His results were strongest for low-ability subjects suggesting the need to ensure integration encoding processes via instructional manipulation is strongest for learners who would not normally use these strategies for meaningful learning. Thus there is positive support for the learning strategy hypothesis, which states that how the learner encodes the material influences what is learned.

Because appropriate prior knowledge and practice in using that knowledge to make meaningful relationships are essential for elaborative activities the use of elaboration may not be effective in improving learning and enhancing retention and may even decrease achievement (Bransford, Stein, & Vye, 1982).

The rehearsal strategies used in this study were designed to provide various degrees of elaboration by focusing attention and allowing time for incoming information to remain in short-term memory long enough to be elaborated upon and encoded for long-term memory.

In this study, the subjects were 148 undergraduate students (69 males, 79 females) enrolled at the Altoona Campus of Penn State University.

The instructional content developed by Dwyer (1972) consisted of a 2,000 word instructional unit describing the parts of the human heart, the internal functions of those parts, and the interrelated simultaneous functioning of those parts with 37 visuals of the heart. This was later revised by streamlining the presentation and reducing the amount of incidental content. The revised script contained approximately 1800 words and utilized 19 visuals of the heart. This study used the approximately 1800 word revised script, but employed 33 of the original 37 2x2 slides from the original 2000 word Dwyer instructional unit. The visuals employed consisted of simple, colored line drawings depicting the form and relative locations of the parts of the heart as they are mentioned in the instruction. The illustrations featured printed words and arrows focusing student attention on the critical parts being described. The visuals were comprised of blue lines on a pink background, and color was used solely to provide color contrast. An example of the visuals used in the instructional unit is shown in Figure 1.

The instructional treatments were presented via an interactive video slide system comprised of the following equipment: an Apple IIe microcomputer, a color monitor with 24 lines and 40 columns, and a Telex Caramate 4000 slide projection system. All subject responses during instruction were restricted to simple keyboard inputs, with the exception of treatment three where an overt visual rehearsal method was used in addition to the computer responses.

The Verbal Tests

Two of the four posttests developed by Dwyer (1972) and revised by Lamberski (1980) were utilized in this study. A description of the two tests as adapted from Dwyer (1978, pp. 45-47) follows.

Drawing Test.

The objective of the drawing test was to evaluate student ability to construct and/or reproduce items in their appropriate context. The drawing test (N = 20 items) provided the students with a numbered list of terms, for example, superior vena cava, aorta, tricuspid valve, and pulmonary vein, corresponding to the parts of the heart discussed in the instructional presentation. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents. An average reliability coefficient of .83 was computed by Dwyer (1978, p. 47) using the Kuder-Richardson Formula 20 Reliability coefficient on a random sampling of previous studies.

The original drawing test was revised slightly in this study to test for the effects of cued and uncued responses. Instead of giving the learner the 20 terms to identify on the heart drawing, only 10 were given and the learner was asked to provide the missing 10 terms from memory, then locate them on the heart drawing. The part of the test having the 10 terms given to the learner was referred to as the cued recall drawing test P1 and the part of the test having no given terms was referred to as the free recall drawing test P2.

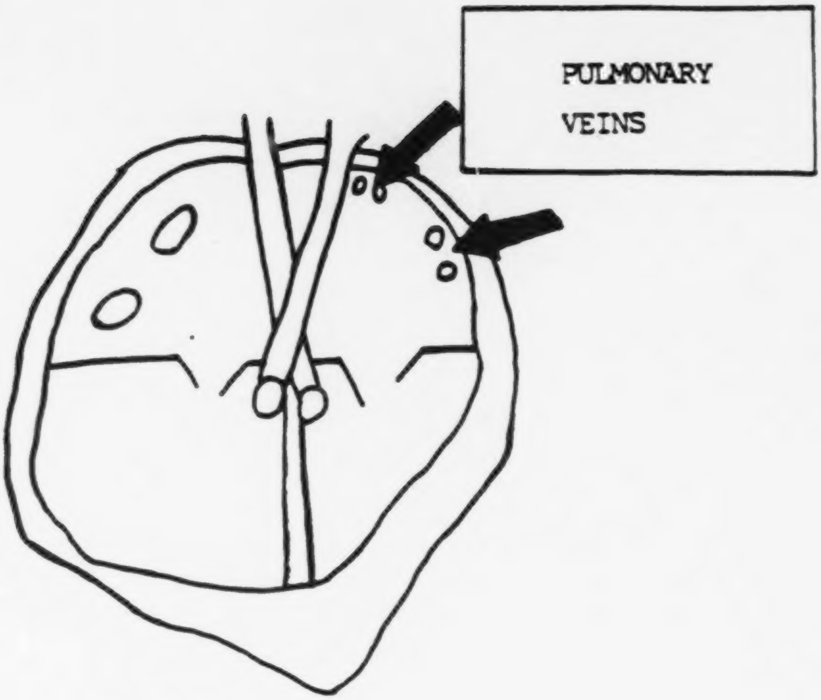

PULMONARY
VEINS

Figure 1. Sample of visuals used in the instructional unit.

Comprehension Test.

The comprehension test consisted of 20 multiple-choice items. Given the location of certain parts of the heart at a particular moment of its functioning, the student was asked to determine the position of other specified parts of the heart at the same time. This test required the students to have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The comprehension test was designed to measure the ability of the individual to use the information being received to explain some other phenomenon. An average reliability of .77 was computed by Dwyer (1978, p. 47) using the Kuder-Richardson Formula 20 Reliability coefficient on a random sampling of previous studies.

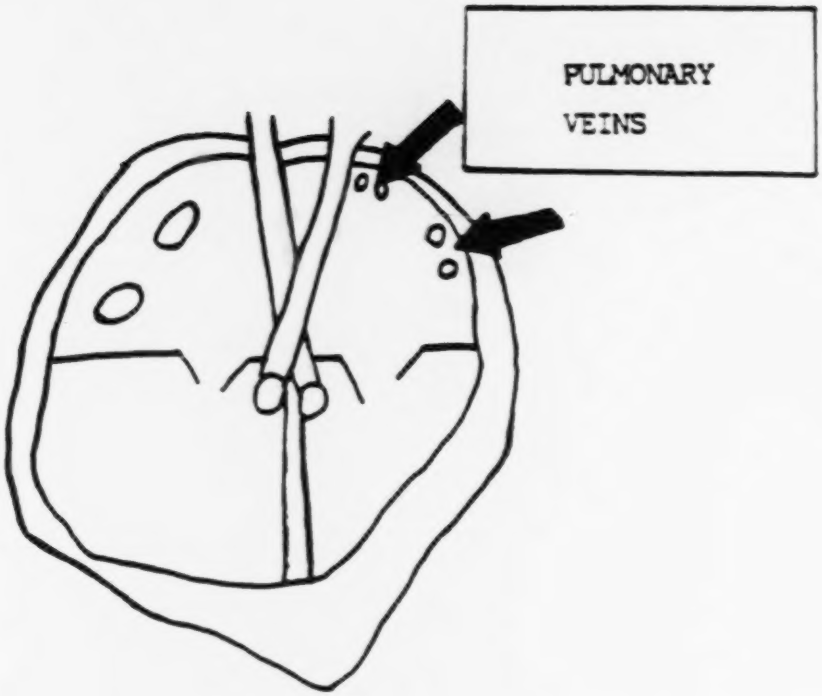
All subjects of this study were given the above three posttests at the completion of the lesson.

The Instructional Treatments

Each of the four instructional treatments in this study contained the same instructional script, visuals, terminology labels, and arrows. The treatments differed in the degree of elaboration employed. The four degrees of elaboration are identified by the treatment number. The control group had no elaboration method; Figure 2 is representative of the presentation received by the control group.

For each of the other three treatments, elaboration was added to the script in increasing degrees. Each of the elaboration treatments had questions added to the script. A pilot test of the heart material conducted during the Summer term 1987 at the Altoona Campus of Penn State University provided 12 areas within the script where students were experiencing difficulty in comprehending the information being presented. The content presented in these 12 areas of the script were found to have been evaluated by a total of 18 questions on the comprehension and drawing tests. Each of these questions had at least 60 percent of the student responses incorrect on the pilot test. Focusing on these 12 areas, questions possessing increasing degrees of elaboration were embedded in the appropriate sections of the script.

The first treatment, TR1, embedded questions at the end of each identified section which required the learner to respond by typing his response on the computer. All responses were accepted by the computer, and no feedback was given as to the correctness of the response. Pressing RETURN after typing in the response caused the computer to proceed to the next part of the lesson.



RETURNING FROM THE LUNGS, THE BLOOD ENTERS THE HEART THROUGH FOUR PULMONARY VEINS AND COLLECTS IN THE LEFT AURICLE; THESE VEIN OPENINGS LIKE THE VENA CAVAS, HAVE NO VALVES. THE LEFT AURICLE THEN CONTRACTS WHEN IT IS FULL, SQUEEZING BLOOD THROUGH THE MITRAL VALVE INTO THE LEFT VENTRICLE.

PRESS RETURN TO CONTINUE.

Figure 2. Sample screen from the control treatment having no elaboration added.

See Figure 3 for an example of the treatment one script with added questions.

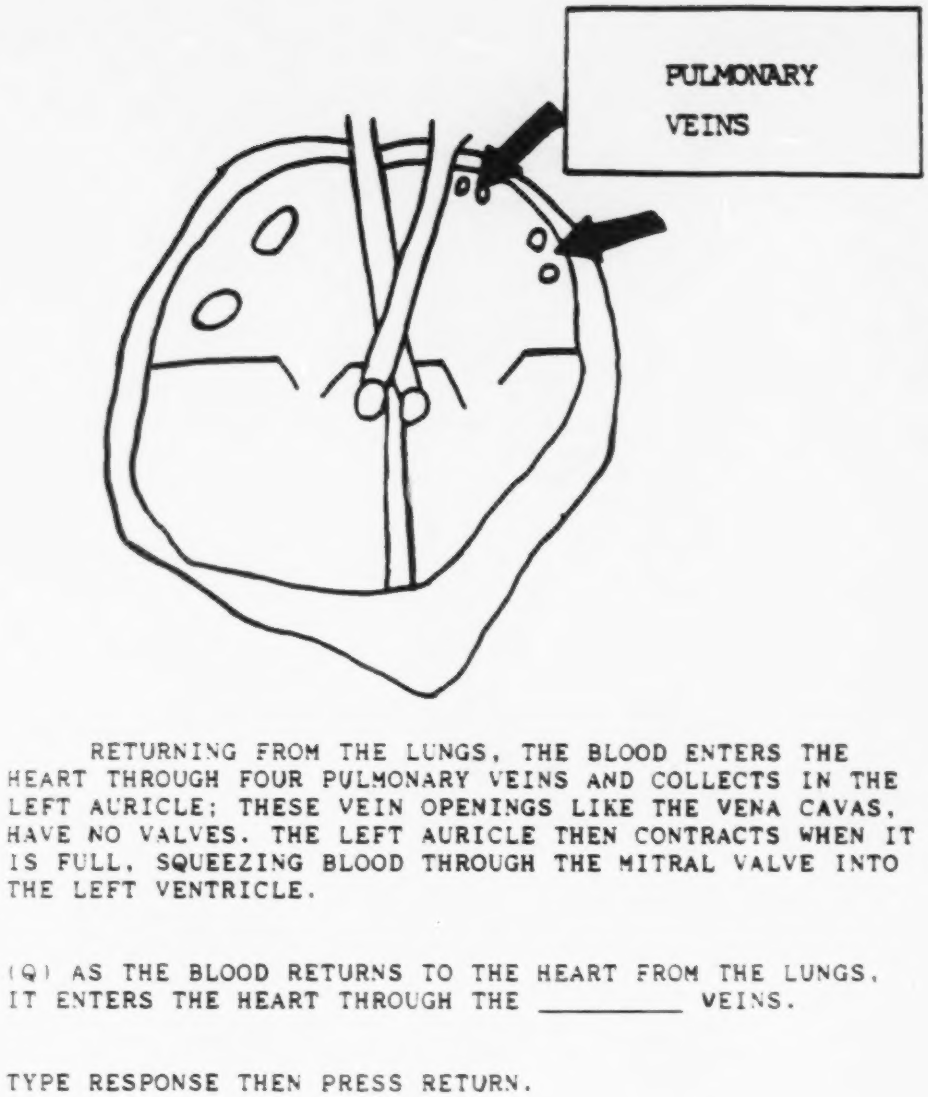
The second treatment, TR2, added the same questions at the end of each identified section as did treatment one, but four response options were provided (A,B,C,D) with one of the choices being the correct answer and the other three acting as distractors. The learner pressed the letter of his choice and then the RETURN key. The response was evaluated by the computer and feedback was provided as to the correctness of the response to the learner. If the correct answer was given the learner was told it was correct and additional information on that particular topic was given to provide further elaboration. If an incorrect response was given the learner was told it was incorrect, why it was incorrect, and what the correct answer should have been. In giving the correct response the same basic elaboration was provided as was given to the learner who identified the correct answer. See Figure 4 for an example of the treatment two script with multiple-choice questions and Figure 5 for a sample of the elaboration provided as feedback.

The third treatment, TR3, had the same question structure as the second treatment, but with still further elaboration provided by an overt visual rehearsal strategy. This rehearsal strategy required the students to shade with colored pencils the specified parts and functions of the heart. The parts and functions to be shaded corresponded to, as closely as possible, the words that were used to answer the questions in treatments one and two. The shading took place on a separate sheet of paper with three provided drawings of the heart similar to those appearing on the lesson slides. See Figure 6 for an example of the treatment three script and Figure 7 for the heart drawings used in the overt visual rehearsal strategy.

Design

The experimental design of this study was a randomized posttest-only control group design. The variables manipulated in the study were the degree of elaboration present in the treatments. There were three treatments possessing different degrees of elaboration and one control treatment which utilized no elaboration, resulting in a total of four levels of the elaboration variable. The dependent variables were the achievement scores on the Comprehension posttest, the two parts of the Drawing posttest, and time-on-instruction.

The physiology 36 question pretest was used to label each treatment's subjects as high or low prior knowledge level. This was accomplished by designating those students whose score was above or equal to the general median score (21) to have high

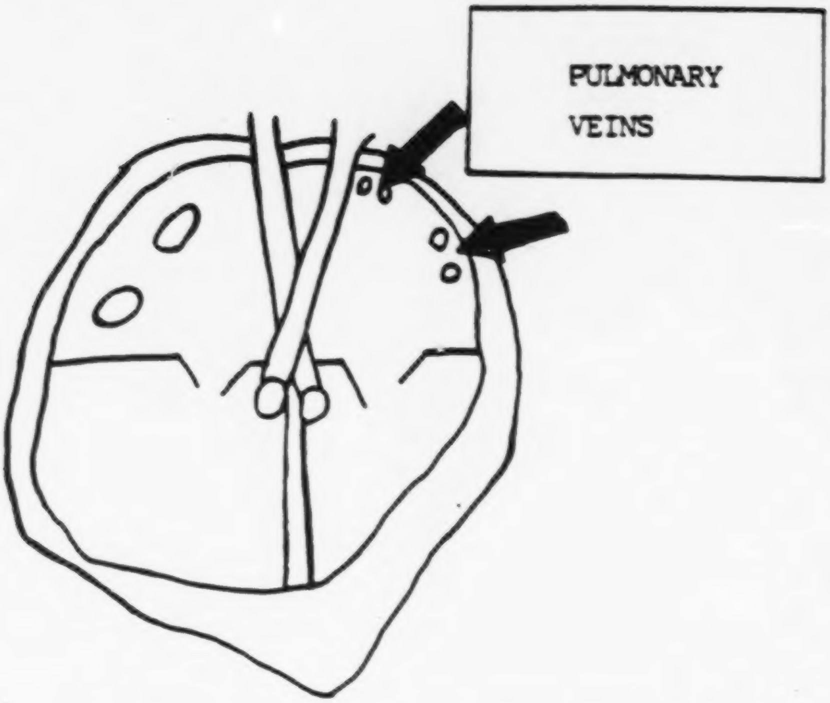


RETURNING FROM THE LUNGS, THE BLOOD ENTERS THE HEART THROUGH FOUR PULMONARY VEINS AND COLLECTS IN THE LEFT AURICLE; THESE VEIN OPENINGS LIKE THE VENA CAVAS, HAVE NO VALVES. THE LEFT AURICLE THEN CONTRACTS WHEN IT IS FULL, SQUEEZING BLOOD THROUGH THE MITRAL VALVE INTO THE LEFT VENTRICLE.

(Q) AS THE BLOOD RETURNS TO THE HEART FROM THE LUNGS, IT ENTERS THE HEART THROUGH THE _________ VEINS.

TYPE RESPONSE THEN PRESS RETURN.

Figure 3. Sample screen from treatment one with questions added, but no feedback.



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(Q) AS THE BLOOD RETURNS TO THE HEART FROM THE LUNGS, IT ENTERS THE HEART THROUGH THE _________ VEINS.

TYPE LETTER OF CHOICE THEN PRESS RETURN.

A) MITRAL
B) VENA CAVA
C) AURICULAR
D) PULMONARY

Figure 4. Sample screen from treatment two with multiple choice questions added and computer generated feedback.

Question #7 - As the blood returns to the heart from the lungs, it enters the heart through the __________ veins.

A) Mitral
B) Vena Cava
C) Auricular
D) Pulmonary

The correct response (D) Pulmonary would result in the following feedback on the computer screen:

CORRECT:

THE "NEW" CLEANSED AND OXYGENATED BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS.

Incorrect response (A) Mitral would have the following feedback on the screen:

INCORRECT:

MITRAL REFERS TO THE VALVE OPENING BETWEEN THE LEFT AURICLE AND THE LEFT VENTRICLE.

REMEMBER, "NEW" BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS AFTER BEING CLEANSED AND OXYGENATED.

Incorrect response (B) Vena Cava would have the following feedback on the screen:

INCORRECT!

THE VENA CAVAS DO ALLOW BLOOD TO ENTER THE HEART FROM ALL PARTS OF THE BODY, BUT NOT FROM THE LUNGS.

REMEMBER, "NEW" BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS AFTER BEING CLEANSED AND OXYGENATED.

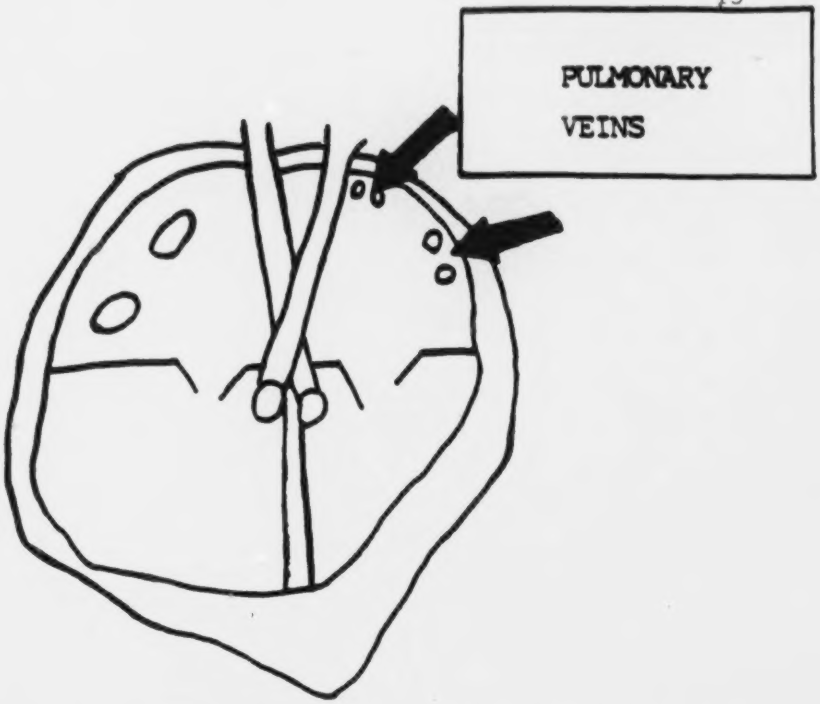
Incorrect response (C) Auricular would have the following feedback on the screen:

INCORRECT!

ALTHOUGH BLOOD RETURNING TO THE HEART FROM THE LUNGS DOES ENTER THE LEFT AURICLE IT ENTERS THROUGH THE PULMONARY VEINS.

REMEMBER, "NEW" BLOOD RETURNS TO THE HEART THROUGH THE PULMONARY VEINS AFTER BEING CLEANSED AND OXYGENATED.

Figure 5. Sample of the elaboration provided as feedback to the responses given in treatments two and three.



RETURNING FROM THE LUNGS, THE BLOOD ENTERS THE HEART THROUGH FOUR PULMONARY VEINS AND COLLECTS IN THE LEFT AURICLE; THESE VEIN OPENINGS LIKE THE VENA CAVAS, HAVE NO VALVES. THE LEFT AURICLE THEN CONTRACTS WHEN IT IS FULL, SQUEEZING BLOOD THROUGH THE MITRAL VALVE INTO THE LEFT VENTRICLE.

* COLOR THE PULMONARY VEINS BLACK.

* COLOR THE MITRAL VALVE YELLOW.

(Q) AS THE BLOOD RETURNS TO THE HEART FROM THE LUNGS, IT ENTERS THE HEART THROUGH THE _________ VEINS.

TYPE LETTER OF CHOICE THEN PRESS RETURN.

A) MITRAL
B) VENA CAVA
C) AURICULAR
D) PULMONARY

Figure 6. Sample screen from treatment three with the overt visual rehearsal strategy added to the multiple choice questions with feedback.

DRAWING PRACTICE FOR TREATMENT #3

14
NAME

FIGURE #1

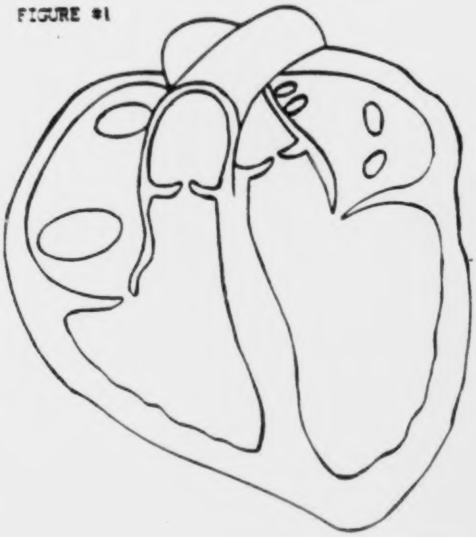
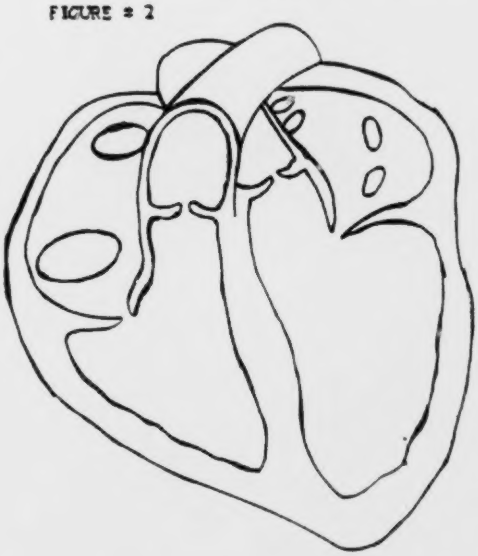


FIGURE # 2



*** NOTE *** Coloring does not have to be fancy; just roughly outline the part of the heart that is described. This is not a test of your artistic abilities!!

FIGURE # 3

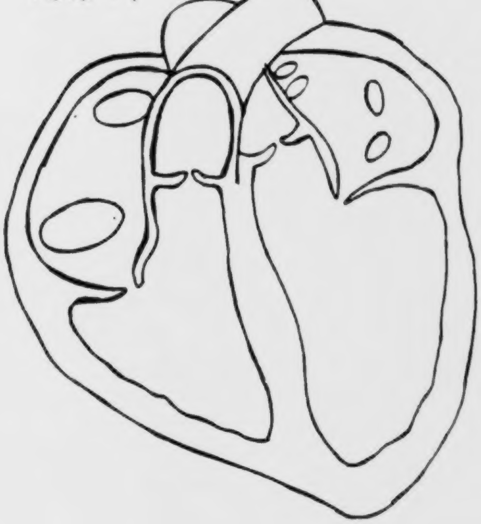


Figure 7. Heart drawings used in overt visual rehearsal strategy in treatment three.

prior knowledge level and those below the mean to have a low prior knowledge level.

Data Analysis Procedures

The computer program SAS (Statistical Analysis System) available from the Computation Center at Penn State University was used to do the statistical analysis on the data collected in this study. Using SAS-GLM (General Linear Model), since each cell had different numbers of subjects, a multivariate analysis of variance, MANOVA, was run to test for an overall effect. A series of univariate ANOVAs was then used for one-factor and two-factor analysis of variance as a follow up to a significant MANOVA.

To test main effects when there was no interaction, the conservative Tukey Studentized Range (HSD) Test was used to compare pairs of means.The Kuder-Richardson 20 was used to generate the reliability coefficient for the multiple-choice tests.

RESULTS

The Physiology Test

All subjects completed the physiology pretest prior to receiving their respective instructional unit. The test was used to verify that proper randomization techniques had been used to assign treatments to subjects by assuring homogeneity of the subjects with respect to prior knowledge related to the instructional unit. The test was also used to determine the prior knowledge level of the subjects.

Stages of Analysis

The general analysis of the collected data was done in two separate stages with each stage examining a different aspect of the study. In the first stage a MANOVA was run to check for overall group and prior knowledge effects and to check for possible group by prior knowledge interactions on the criterion tests for the four treatment groups. If significance was found at the .05 alpha level, then follow-up tests using univariate ANOVAs and Tukey's HSD test were run. If no significant difference was found in the first stage the analysis was terminated.

In the second stage, the concept of efficiency was introduced with each subject's scores on the criterion tests being divided by his total time-on-instruction to provide an efficiency score for each test. A MANOVA was then run to check for overall group and prior knowledge effects and to look for possible group by prior knowledge interactions using these efficiency scores. Significant results were then analyzed further using follow-up ANOVAs and Tukey HSD tests.

Findings

Time-on-Instruction

Finding that treatment TR3 had significantly more time-on-instruction was no surprise considering the extra time spent in doing the visual rehearsal strategy in treatment TR3. Treatments TR1 and TR2, although not taking nearly the time of TR3, still spent significantly more time-on-instruction than the Control group. A significant difference in time spent on instruction was expected with the increasing degree of elaboration taking more time to complete. In all cases this additional time spent on instruction resulted in higher achievement scores on all the criterion tests. The decision to adopt a treatment taking more time to complete would depend on the degree of mastery required and the time available for instruction.

The Comprehension Test

Although the first stage analysis found a significant difference in achievement among the four treatment groups there was no significant difference in achievement on the comprehension test. The increasing degrees of elaboration and the different types of elaboration did not increase the achievement on the comprehension test significantly.

The introduction of prior knowledge levels in the analysis did find, however, that high prior knowledge subjects scored significantly higher than low prior knowledge subjects on the comprehension test. It was felt that increasing the amount of elaboration would help decrease the significant difference between achievement scores of the two prior knowledge levels, but this did not occur. A possible explanation for this failure to overcome these existing differences might be the difficulty of the test material. The mean score on the comprehension test was 11.392 out of a possible 20 with the high prior knowledge subjects having a mean score of 12.432 and the low prior knowledge subjects having a mean score of 10.351. With so much room for improvement it was unlikely the high prior knowledge subjects experienced a ceiling effect which would have allowed the lower prior knowledge subjects to close the gap between their scores.

The mean scores of the high prior knowledge subjects on the comprehension test ranged from a low of 12.083 in treatment group TR3 to a high of 12.824 in treatment group TR2, a difference of 0.741. The range for the low prior knowledge subjects was from 8.800 in the Control group to a high of 11.313 in treatment group TR3, a difference of 2.513. Although the difference in treatment group scores for the high and low prior knowledge subjects were not statistically significant, they did suggest that the increasing degrees of elaboration helped the low prior knowledge subjects more than the high prior knowledge subjects on the comprehension test.

Although not a significant difference, the high prior knowledge subjects spent on average 36.837 minutes on instruction while the low prior knowledge subjects spent on average 33.946 minutes on instruction. It would seem that the high prior knowledge subjects spent at least as much time on instruction as the low prior knowledge subjects, but they were unable to improve their achievement significantly on the comprehension test regardless of the amount or kind of elaboration that was used.

A further consideration might be that the six questions that were elaborated upon in the comprehension test were concerned with functions of certain parts of the heart at specific times, but the increased elaboration in treatment TR3 was visually oriented and more likely to effect achievement on the drawing tests than on the comprehension test.

The consideration of efficiency scores in the second stage of the analysis also showed the achievement of the high prior knowledge subjects to be significantly better than the low prior knowledge subjects on the comprehension test. This result pointed out that any difference in time spent on instruction between the two prior knowledge levels was not a significant factor in their achievement scores. As mentioned earlier, the high prior knowledge subjects did spend more time (approximately three minutes) on instruction than did the low prior knowledge subjects. Since efficiency scores were determined by dividing each test score by total time-on-instruction for each subject, a significant difference in time-on-instruction between two subjects having comparable raw scores would result in the subject who spent more time-on-instruction having a lower efficiency score. Since the high prior knowledge subjects still scored significantly better than the low prior knowledge subjects when efficiency scores were used, this would seem to imply that achievement increased with time-on-instruction so that the overall ratio of achievement score to time-on-instruction remained about the same for both prior knowledge groups.

Using efficiency scores resulted in the first significant difference between achievement of the treatment groups on the comprehension test. No difference was found when raw scores were used, but with the efficiency scores the treatment with the most elaboration TR3 scored significantly lower than all the other treatments. This result was not surprising considering the mean increase in achievement from the Control group to TR3 on the comprehension test was 0.98, but the amount of time spent on instruction more than doubled.

Although the difference in time-on-instruction between the Control group and treatment groups TR2 and TR3 was significant, their raw scores were not, which resulted in the Control group efficiency score being significantly higher than the efficiency scores of treatment groups TR2 and TR3. The fact that no significant difference in time-on-instruction was found between treatment groups TR1 and TR2 could help explain why no difference in achievement was found between these treatments when efficiency scores were used. The significance of these results was found in the realization that the considerable amount of time spent on instruction in treatment TR3 not only failed to increase achievement proportionately on the comprehension test but also resulted in a lower efficiency score. This finding would seem to suggest that improving achievement is not simply a matter of spending more time-on-instruction. Another notable point was that although the difference in time spent on instruction was significant between Control and treatment TR1, there was no significant difference between their efficiency scores which would imply achievement increased sufficiently in treatment TR1 to offset the additional time spent. A similar observation would apply for treatments TR1 and TR2. This would suggest that the increase in achievement on the comprehension test gained by increasing the degrees of elaboration in the first three treatments was a worthwhile use of time spent on instruction. Treatment TR3 did not satisfy this condition because its considerable increase in time-on-instruction was not offset by a comparable increase in achievement on the comprehension test.

One final point on the comprehension test results would be to consider the fact that only 6 question areas received elaboration out of the 20 questions on the test. It would seem logical to assume that any increase in achievement on these 6 questions would not have the same effect as increases in the 6 questions elaborated upon in the drawing tests which have only 10 questions each.

Drawing Test P1

The significant difference in achievement between the treatment groups on Drawing test P1 found in the first stage of the analysis showed treatment TR3 to be significantly better than the other treatments. Since treatment TR3 had a visual rehearsal strategy which was directly related to the information tested in Drawing test P1 it was not surprising that this treatment scored significantly better than the other treatments which did not have this additional visual component. Although the mean achievement scores in the first two treatments TR1 and TR2 were not significantly higher than the score of the Control group on Drawing test P1 they were higher (Control 5.11 to TR1 and TR2 5.49). This would seem to possibly indicate that the elaboration in treatments TR1 and TR2, while having some effect, did not effect achievement like treatment TR3 (mean score 7.55 out of 10). Previous research has shown that visuals such as the line drawings in this study used in conjunction with prose instruction do improve student learning and consequent ability to reproduce the visuals in a drawing test. However, in a study using similar material and treatments by Dwyer, 1984 no significant difference was found on the drawing test. The fact that Drawing test P1 was a test of cued recall evaluating the subject's ability to construct and/or reproduce items in their appropriate context was probably the main reason why treatments TR1 and TR2 did not show much effect since they did not concentrate on the visual aspects of the heart material. The increased elaboration in TR2 over TR1 was of little consequence as the content elaborated upon was not tested in P1.

As with the Comprehension test, the high prior knowledge subjects did significantly better than the low prior knowledge subjects on Drawing test P1. The difference in mean achievement scores for the high and low prior knowledge subjects were almost identical for each of the treatments showing that the elaboration had the same effect on both prior knowledge levels on Drawing test P1. Both prior knowledge levels increased their achievement as the amount of elaboration increased on the targeted material.

Using efficiency scores resulted in the Control group achieving significantly better than treatment TR3 on Drawing test P1, but no difference was found between the other treatments. This seemed to validate the earlier findings that treatments TR1 and TR2 had very little effect on achievement on Drawing test P1. The earlier mentioned study done by Dwyer, 1984 used the same content and similar tests but found no significant difference on the drawing test. The major difference between her study and this one was the use of computer-generated feedback that was also included in TR3. Perhaps this elaboration while not very effective on its own (TR2) may interact with the overt visual rehearsal strategy to produce an effective means of presenting the material.

Drawing Test P2

The only difference between Drawing tests P1 and P2 was the cues present in P1 were absent in P2. The results were similar in that treatment TR3 was again significantly better than the other treatment groups when raw scores were used and considerably worse than the other groups when efficiency scores were used. The similarity ends when the treatments are compared for each test. The achievement on Drawing test P2 was the only one where each increase in elaboration resulted in a noticeable increase in achievement from the previous treatment. Achievement on the Comprehension test actually dropped in treatment TR2 while achievement in Drawing test P1 showed practically no increase from the Control to treatment TR2. Perhaps the elaboration done in treatments TR1 and TR2 while not improving achievement on Drawing test P1 with cued recall did provide the needed help in Drawing test P2 where recall cues were not provided. The rehearsal strategy of typing responses and answering questions present in TR1 and TR2 may have helped to further implant these terms into long-term memory. The achievement of the prior knowledge levels on Drawing test P2 were similar to those on Drawing test P1 with the high prior knowledge subjects having approximately the same difference in achievement over the low prior knowledge subjects in each treatment. The significance of Drawing test P2 seems to lie in the fact that it did not provide cues to help the subject recall the names for the parts of the heart so that they could then be located on the drawing of the heart. Because these cues were not given the subject had to remember them from the given instruction and at this point the additional elaboration given in the treatments may have provided some cues to help the subject retrieve this information from long-term memory.

Summary of Results

The hypotheses presented in this study and the results for each are as follows:

H1: There will be an insignificant difference among achievement scores of the four presentation formats, control, embedded questions (TR1), computer-generated feedback (TR2), and computer-generated feedback with a visual rehearsal strategy (TR3).

This hypothesis was rejected as a significant difference was found between the achievement of the four presentation formats with treatment TR3 having the highest achievement scores on all three criterion tests.

H2: There will be an insignificant interaction between prior knowledge level and type of rehearsal strategy among students in the four treatment groups.

This hypothesis was retained as the subjects with high prior knowledge level achieved significantly higher scores on all the criterion tests than the low prior knowledge subjects regardless of the treatment.

H3: There will be insignificant differences in lesson completion time between types of rehearsal strategies among students on tests measuring different educational objectives.

This hypothesis was rejected as a significant difference was found between the time-on-instruction for each of the treatments with TR3 > TR2 > TR1 > Control. As the degree of elaboration increased the subjects spent more time-on-instruction even though the instruction was self-paced.

H4: There will be an insignificant difference in efficiency scores on tests measuring different educational objectives by treatment group.

This hypothesis was also rejected. As the degree of elaboration increased the time-on-instruction also increased yielding a significant increase in achievement on the three criterion tests. Although the test scores did increase significantly, the efficiency scores of each treatment group diminished as the amount of time spent on instruction increased for each of the criterion tests. Control > TR1 > TR2 > TR3.

Conclusions

The results of this study have provided some interesting points for consideration before planning any instruction using increasing degrees of elaboration. As with most research these findings can only suggest a possible path to follow when preparing instruction, but a path nonetheless.

The fact that elaboration works seems to be rather clearly shown. The effect of elaboration on high prior knowledge subjects can be both helpful and harmful depending on the circumstances of the instruction. If the content is rather easy the time taken for elaboration is probably not time well spent for the high prior knowledge subject and could lead to boredom and a subsequent decrease in achievement. The effect of elaboration on the low prior knowledge subject for easier material is much more positive as it allows this type learner to acquire material that would be missed without the extra elaboration. The extra time spent on instruction because of the elaboration also helps the low prior knowledge learner to better organize the material in short-term memory which results in better retention and retrieval from long-term memory. With harder material the effect of elaboration is going to depend to a large degree on the amount of elaboration and time spent on the instruction with the lower prior knowledge learners requiring considerably more of both than the higher prior knowledge learners.

The efficiency of instruction using elaboration will generally be rather poor as more elaboration goes hand in hand with more time spent on instruction. The results of this study seemed to indicate that the gains in achievement were not commensurate with the amount of time spent on the instruction.

Subjects with high prior knowledge will consistently score better than subjects with low prior knowledge regardless of the kind or amount of elaboration. On tests of increasing cognitive difficulty both groups will benefit about the same from the extra elaboration.

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Title:

Adults' Perceptions of Concept Learning Outcomes: An Initial Study and Discussion

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ADULTS' PERCEPTIONS OF CONCEPT LEARNING OUTCOMES: AN INITIAL STUDY AND DISCUSSION

The purpose of this paper is twofold: (1) to report an empirical study of educators' perceptions of learning concepts, and (2) based on the study's findings and a review of cognitive learning literature, to argue for an expanded view of conceptual knowledge and its role in education and training.

Changing Views of Concept Learning

Concepts are essentially categories that people use to organize their worlds and give order and meaning to their experiences. People learn concepts both by interacting naturally with their environments and through school and formal learning experiences (Brown, Collins, & Duguid, 1989). Also, people often spontaneously invent concepts to solve local problems.

Over the past few years, several instructional design theorists have suggested revisions in the traditional view of concept learning (Tennyson & Cocchiarella, 1986; Wilson, 1986; Newby & Stepich, 1987; Tessmer, Wilson, & Driscoll, 1990). According to these researchers, the well-established "concept attainment" paradigm in instructional design literature (e.g., Markle, 1975; Merrill & Tennyson, 1977) does not take into account advances in cognitive psychology explaining how people acquire conceptual structures. Concepts should no longer be thought of as being completely defined by attributes-based definitions. Many concepts may be ill-defined or "fuzzy", and many concepts have rich connotations and shades of meaning whose understanding is necessary to make full use of the concept. Recommended instructional strategies include greater use of analogies , "prototype" examples, and learning strategies, and greater use of the concept in a variety of problem-solving settings.

Declarative and Procedural Components of Concepts

Historically, instructional design models have addressed a problem common in formal school settings, in which a definition may be learned by rote, and students are never required to actually use the definition to classify sample cases. Largely as a response to schools' preoccupation with inert, declarative knowledge, instructional designers emphasized *classification* performance; that is, given a newly encountered case, can the student identify that case as being a member of the concept category? The roots of viewing concepts as classification skills can be traced back to Aristotle, and more recently, to Thorndike and Hull's laboratory studies on human learning. Basically, students capable of classifying new cases were said to know the concept. Gagne (1985), following Anderson's (1983) theory of cognitive learning, calls this kind of performance "pattern matching" and treats it as a kind of procedural skill. Like most procedural knowledge, concept classification performance can be acquired and refined through repeated practice with feedback. Example classification strategies form a major part of traditional recommendations for teaching concepts, such as the use of divergent examples, proceeding from easy to complex cases, highlighting key attributes, and providing explanatory or elaborative feedback to missed practice items.

Notwithstanding instructional design emphasis on procedural aspects, language experts have long understood that in addition to denotations (the set of cases the term refers to), terms or concepts also have connotations (the meaning or properties suggested by the term). A person who has learned what a sea otter is, for example, should be able to identify a sea otter from a harbor seal, but should also be able to tell us something significant about the animal. One could imagine a student narrowly trained to classify cases but lacking in declarative knowledge about the subject. Such a student could "use" the pattern-matching skills to identify cases, but may not have the least notion about what the classification *meant.* Equally disturbing, the lack of meaningful understanding about the category would inhibit the concept's effective use in most realistic problem-solving situations. The student would probably not understand when and where to use the concept spontaneously to achieve a particular goal, or to draw inferences from its meaning. An optimal learning of concepts, then, would seem to include components of both declarative and procedural knowledge, combined in a way that made the concept meaningful and usable in real-life situations.

***Really* Learning Concepts: A Survey of Educators**

Persuaded that most educators would agree that both declarative and procedural aspects are important outcomes, we conducted an exploratory study to examine the kinds of learning indicators educators would accept as evidence of concept learning. We asked students (N=56) in three graduate education classes to respond to the following scenario: You are teaching college sophomores of medium to above average intelligence with no prior knowledge of the topic. What performances would serve as indicators that students had really learned the concepts *glasnost*, *snow leopard*, and *justice*, representing a sampling of concrete and defined concepts. Subjects filled in blank spaces with their choice of learning indicators.

NUMBER AND TYPE OF CONCEPT LEARNING INDICATORS
(Total respondents = 56; responses = 339)

TOTAL	CONCEPT LEARNING INDICATOR
127	**Definitions and defining attributes**
62	Describe defining attributes
38	Give the definition
27	Describe the concept
66	**Examples and nonexamples**
38	Classify/recognize cases
28	Generate examples
62	**Elaboration**
45	Describe concept elements (not defining attributes)
5	Teach the concept to others
5	Relate the concept to other concepts
4	Distinguish between concepts by elements
3	Explain the concept
84	**Use**
22	Describe effects/implications
20	Use in a sentence/story
17	Solve problems using the concept
9	Critique situations and actions using the concept
9	Write a story about the concept
7	Role-play

A major finding is the broad array of concept performances that subjects listed. Table 1 summarizes the responses according to type of performance suggested. The 56 respondents generated 339 performances for the 3 concepts. Of those performances, 38 suggested concept classification following traditional instructional design models. However, a large number (217) of other performances like "discuss", "compare", "describe", "draw", "give an example" were elicited, suggesting the commonsense prominence of having a declarative understanding of the meaning of the concept. In addition, using the concept in a variety of creative ways, and drawing inferences from it were also thought to be valid indicators of concept learning. Eighty-four responses mentioned uses such as problem solving, predicting effects, role-playing, and using the concept in conversation or writing.

An interesting point made by several researchers (e.g., Howard, 1988) and confirmed by our study's findings is the schema-like role played by many concepts. Schemas, according to models of cognitive processing, consist of a whole network of related knowledge, centered around a particular setting or idea. Many concepts, such as 'justice' in our study, are rich in their associations with other concepts. The web of relations together may constitute a schema for that concept, so that concepts become schema-like in their complexity. While it is important to differentiate between the concept itself (the category and its basic meaning) and its full-blown schema, an understanding of how a concept is related to other knowledge can provide a basis for prescribing effective use of the concept for solving significant context-based problems. The instructional designer's emphasis of "using" concepts can then be expanded beyond classification performance to problem-solving and other divergent uses, such as making inferences and developing analogies. In order to make creative use of concepts, declarative, procedural, and *metacognitive* knowledge must be acquired by the learner. We would recommend an instructional design model that included these components with respect to concept learning as well as all learning outcomes.

New Methods for Teaching Concepts

The expanded notion of concept learning described above has definite implications for concept teaching strategies. Summarized below are several strategies that include the declarative and problem-solving aspects of concept learning as well as procedural classification skills.

1. ***Teaching with analogies.*** Analogies enable learners to connect novel conceptual information with their prior knowledge, thus establishing a familiar structure for the new concept. Concept instruction through analogy can be so powerful that the proper analogy must be carefully chosen (Striley, 1988), and its boundaries (comparatives) to the concept explained (Feltovich, et. al., 1988).

Several theorists prescribe the use of analogies for defined (abstract) concept learning (Ortony, 1975; Newby & Stepich, 1987). However, analogies can also be used for concrete concepts such as "snow leopard." This is worth noting since most designers seem to forget that visual/aural/tactile information (R. Gagne's "concrete concepts") can be as complex and/or difficult to learn as defined concepts. Biederman & Shiffrar (1987) present an interesting illustration of this point. They cite an analogy used by chicken sexers, who cultivate their subtle identification skills over years of experience. To identify male chickens, their genitals are conceptualized as looking like a watermelon or a ball, while the female's look like an upside down pine tree (p. 643).

2. ***Encouragement of learning strategies.*** Various learning strategies can be invoked by learners to aid the encoding of concept information. Concept mapping and structuring (Jonassen, 1984; Vaughan, 1984; Tessmer and Jonassen, 1988) help students organize definitions, examples, and properties of concepts, as well as semantic/inferential relations among other concepts. For classification tasks, advance task instructions on learning and performance expectations can activate concept learning strategies in students (Ellis, et. al., 1986). If concept inference or use is an objective of the instruction, these advance instructions may help the learner to generate the proper problem-solving stance toward the content.

3. ***Use and inference practice.*** Programs such as the Higher Order Thinking Skills program (Pogrow, 1985) have successfully encouraged students to manipulate conceptual information by creatively using the concept in various symbol systems and contexts to broaden their meanings. For example, using the concept of reinforcement in lab experiments, teaching, and business contexts can broaden the learner's understanding of what reinforcement entails, which can promote the learner's transfer of the concept to contexts not originally studied (e.g. for self-management).

Using a concept in different symbol systems occurs, for example, when learners read about the social hierarchy of whales and draw sketches depicting their understanding of "hierarchy." This process of translating from one code to another -- in this case, verbal to visual -- has been termed *transmediation* (Suhor, 1982) and has assisted learners in gaining new insights and broadened understandings about concepts (Siegel, 1985).

Concept use instruction can proceed through several stages. Learners can begin by paraphrasing the concept definition of attributes (R. Anderson, 1973) and conversing about the concepts (Markle, 1975; Wilson & Tessmer, 1989), then move to utilizing the concept in conversations and other communications, and finally to using the concept with other declarative or procedural knowledge to solve problems (Wilson & Tessmer, 1989).

4. Alternative strategies for classification performance. A variety of alternate presentation strategies can be used to supplement the standard definition-plus-examples/nonexamples strategies used in example classification training. Many of these strategies have been advocated by instructional theorists over the years.

For example, displaying coordinate concepts in structural outlines such as concept trees has facilitated coordinate concept classification (e.g., Tessmer & Driscoll, 1986), and may be particularly effective with adult learners (Bower, 1970). For classification practice, concept games and simulations are a little-used strategy that puts the learner into scenarios that elicit classification performance in ways that differ from standard concept example practice (Tessmer, Jonassen & Caverly, 1989). Particularly, concept simulations mimic the real-world situations in which the learner will use concept classification, increasing the probability of transfer. To create concept examples/nonexamples that maximize generalization and discrimination, the Rational Set Generator (Driscoll & Tessmer, 1985; Tessmer & Driscoll, 1986) can be used to design sequences of coordinate concept examples and nonexamples.

Hierarchical displays facilitate the learning and organization of the declarative component of concept classifying, while rational sets, games and concepts facilitate mastery of the classification skills of concept learning (E. Gagne, 1985). When used with analogies, and use and inference practice, the aforesaid interventions extend what Reigeluth (1983) would call the meaningfulness of the concept.

5. ***Determining qualities of concepts to be learned.*** While the distinction between defined and concrete concepts is a well-established part of design practice, a more fine-grained analysis of concept qualities could lead to more appropriate instruction. The ***complexity*** of concepts is an important dimension to consider, for example. Complexity is determined by the amount and unfamiliarity of information to be learned to meet concept learning objectives.

Contrary to Newby and Stepich's (1987) emphasis on abstract (defined) concepts, concrete concepts may be as complex and difficult to learn as defined concepts, as indicated in the chicken sexing sample above. Concepts may also vary in their ***precision***; many everyday concepts are ill-defined or "fuzzy," defying standard definitional instruction (B. Wilson, 1986), such as concepts like "time" or "esprit de corp." Concepts may be ***relational, conjunctive***, or ***disjunctive*** (Bruner, Goodnow, Austin, 1956), each requiring appropriate instructional support. Most important, designers must learn to classify concepts by the ***content*** and ***purposes*** of the instruction. The meaning of any given concept and its learning objectives frequently depend on these two factors, not upon a standard invariant meaning and standard classification performance. The way people use concepts is context dependent (Whitehead, 1954; Carroll, 1964; Barsalou, 1985). Thus, just as context is examined in a front-end analysis for large-scale instruction, so context should be analyzed when teaching concepts. What are the different uses of the concept by someone who "really understands" it? What are the variable subjects or situations in which it will be used? These are context analysis questions.

Conclusion

In this paper, we have presented an exploratory study that seems to confirm a correspondence between adults; perceptions of concepts and emerging views based on cognition models. This way of looking at concepts takes into account the declarative and metacognitive components of concept learning and use. Implications for instructional design have been outlined. The paper is largely a response to traditional concept teaching models that focused nearly exclusively on the procedural components of concept use. Using R. Gagne's (1985) taxonomy of learning outcomes as an example, we are recommending that the "intellectual skill" of concept classification be integrated with the "verbal information" that makes the concept meaningful, and to additional skills that encourage concept use and inference. Concepts taught in this broader way will be more likely to be used in realistic performance situations.

The obvious danger in broadening the view of concepts and concept teaching is that the notion will become ill-focused and lack prescriptive power. We believe that, on the contrary, a broader approach to concept learning can help bring our instructional models back into alignment with everyday teaching and learning. A continuing effort to articulate instructional strategies such as inferences, simulations, scenario-based instruction, and case studies will help concepts come alive to learners.

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Title:

Assessing Knowledge Structures

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ASSESSING KNOWLEDGE STRUCTURES

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This paper presents two general approaches to the assessment of knowledge structures. The first approach entails the building of empirical evidence to support cognitive theory. This type of assessment is concerned with attempting to prove the existence of various knowledge structures, that is, evidence that leads to the construct validity of these metaphorical ideas. The second approach is dependent upon the first task and attempts to look at the actual content within the structure. That is, assuming that such constructs (strtuctures) exist, then what methods can be used to determine the specific relationships of ideas within a structure?

DIFFERENT TYPES OF KNOWLEDGE REPRESENTATION

It will be helpful to distinguish between different assumptions regarding the representation of knowledge in memory. This will affect how this knowledge is structured, and consequently how it is assessed. There is not complete agreement in current cognitive psychology as to the exact definition of the terms that I have used, but I have grouped some common constructs together in an attempt to be parsimonious.

Propositions/semantic memory. This type of representation claims that knowledge is stored in a way that is not a direct representation of the outside world. Rather, knowledge is abstracted and stored in the form of propositions. These are relationships between *subjects* and *predicates*. Schank and Abelson (1977) have expressed the idea that there are a limited number of relationships that can be represented generically, in their Conceptual Dependency theory. Proposition representations are assumed to be declarative knowledge, that is, knowledge of "what" as opposed to knowledge of "how." (E. Gagne, 1985). This type of knowledge would equate with "verbal information" in R.M. Gagne's (1979) taxonomy and with the "remember" level in Merrill's (1983) Component Display Theory.

Productions. When knowledge can be applied, it can be thought of as existing in a production representation. This is a series of "if/then" statements that allows the subject to react to the outside world. Implicit in this representation form is the idea that an if/then statement can be linked to other if/then statements creating a *production system* (E. Gagne, 1985). A production system would underlie all complex forms of performance, both cognitive and psychomotor. This type of knowledge would roughly equate with "intellectual skills" and "motor skills" in R.M. Gagne's (1979) taxonomy and the "use" and "find" levels in Merrill's (1983) Component Display Theory.

Schemata/scripts. Although the most ambiguous of the representation forms, a schema or a script can generally be thought of as knowledge of a prototypical situation. The situation activates an existing script or schema in which there are default values for the most typical variables that will be encountered in the situation. The learner can go beyond the information given by using these default values for both comprehension and creating inferences. Schemata and scripts are essential in the comprehension process, because they set up expectations of the environment regarding what to expect in a situation. More central actions may be more easily recalled and can be used as guides for top-down processing (Galambos, 1986). It would seem that a schema or a script could be thought of as an integrated system of propositions and productions since both need to interact in controlling perception, understanding, and behavior.

Images/episodic memory/iconic memory/spatial knowledge. There are similarities and differences between these ideas of representation forms. Essentially, each is based on the idea that knowledge may be stored in a literal "picture" form, as opposed to an abstracted representation such as a proposition.

KNOWLEDGE STRUCTURE

This section on assessing knowledge structure briefly details several methods for assessing structure assuming a proposition/semantic representation, a schema based representation, a production representation, and an iconic/episodic representation. As was previously mentioned, note that some of these techniques are concerned with proving the existence of the construct while others are used to assess the current content of the structure.

SEMANTIC/PROPOSITION REPRESENTATION

These tasks and tests do not reveal the specific contents of the propositions in memory. Rather, they seek to confirm the existence of this type of representation.

Reading time tests--This basic test is used to support the idea of propositions. A sentence is broken in propositions by the experimenter. The subject's reading time is measured. Reading time correlates strongly with number of propositions included in each sentence, because it is assumed that it takes time to process each different proposition. (Kintsch & Keenan, 1973, cited in Robertson, 1986)

Semantic recall tests--Subjects are given a paragraph to read. They are later shown sentences which are similar to some of the sentences contained in the original paragraph. The fact that subjects will often believe that they have seen a sentence that is similar in meaning--but not actually incurred in the paragraph--supports the idea that information may be stored in proposition form.

Hierarchical timing tests--It was assumed by Collins and Quillian (1969, cited in Norman, 1976) that learners structure knowledge of a concept in a hierarchical manner, with essential features at the higher levels. Lower levels contain only features that separate the item from other items at the same level. This was measured with timing tests, assuming that it took more time to process comparisons between items at different levels than it would take to compare parallel items in one of the branches of the hierarchy, because of the processing time needed to search through the hierarchy (E. Gagne, 1985). Although continued research evidence disproved much of this theory, the timing technique may still have value (see *generating examples*, below).

SCHEMATA/SCRIPTS/FRAMES AS REPRESENTATIONS

These tests are generally based on the assumption of semantic proximity, that is, that related ideas are stored close to each other in cognitive structure (Nagy, 1983). Most of these assessment procedures deal with integrated propositions, and occasionally propositions integrated with production systems.

Pattern notes--Subjects are given a word at the center of a blank page of paper and asked to free associate other words which are then linked together. However, the student-created linkages do not specify the relationships between the words. Pattern notes are scored by counting the number of links between words, and creating an intercorrelation matrix. This test has concurrent validity with word association tests (Jonassesn, 1987).

Word association tests-- There are two types: (1) Free word association: subjects are given a word and asked to list the first word that comes to mind when thinking of the first word. Below it, the second word that comes to mind is listed, etc. Chaining is not allowed, and words are not to be repeated. This list is then correlated with the content structure (Preece, 1976). (2) Controlled word association: subjects are given lists of words and asked to rank order them according to which words are most related in meaning. (Jonassen, 1987).

Tree construction tasks-- Subjects are required to construct a linear graph in which the intersections are words and the connecting lines are the relationships. However, structures may be constrained by this type of pattern. (Jonassesn, 1987)

Concept maps--Subjects are asked to link concepts that relate to other concepts in a hierarchical pattern. The links (representing the relationships between concepts) are then labeled. It is assumed that this is a "rubber" hierarchy, that is, that the sequence of connected concepts could be subsumed in several hierarchies of equal validity. Nowack and Gowan (1984) have devised a scoring system in which concept maps can be compared to content structure.

Membership decision tasks--This type of task attempts to determine the typical actions within a script. "Subjects are timed as they decide whether an action is involved in performing a given activity" (Galambos, 1986). Subjects are first given an action phrase followed by an activity phrase. The subject must choose whether or not the action is a component of the activity. This measures the centrality of the action, that is, how important the action is to the activity.

Generating examples--Subjects are given a category and asked to generate members or instances of the category. The "production frequency" (the speed and order of generation of the instances) determines how closely any instance is related to the superordinate category. As related to Collins and Loftus (1975) spreading activation theory, one can determine that, "the greater the semantic relatedness of an instance and a category, the faster the decision that the instance is a member of the category." (Eysenck, 1987).

Conceptual models--These are essentially concept maps of content structure as compared to cognitive structure. These models contain node links representing concepts, and the linkages are labeled, for example, "is a consequence of; is one feature of, etc." (Neill, 1970 cited in Romiszowski, 1981). Although not used for assessing cognitive structure, this technique could easily be adapted.

Concept typicality ratings--In this task, subjects are given a superordinate category, and then asked to rate the typicality of different given instances of the category. It is assumed that more typical instances are more highly related--and in closer semantic proximity in structure--than less typical instances (Eysenck, 1987).

PRODUCTION REPRESENTATION

A production is closely related to the idea of information processing, and can also be thought of as the "executive subroutine" that controls psychomotor activities. A production is said to underlie all skilled performance, be it cognitive or physical.

Subtraction technique for assessing processing--These techniques are used to measure the time needed to complete various tasks. It is assumed that if the processing takes place as theorized, that this will correlate with the time needed to complete the mental task. By varying only one element of the task, and consequently determining a change in processing time, the experimenter infers that processing took place as theorized. This type of technique has been used to study information processing models of cognition and perception (E. Gagne, 1985)

Actual tasks--Because it is assumed that a production system underlies and controls skilled automatic performance, the absence of the skill, would point to an incomplete production system. According to R.M. Gagne (1979), to test for intellectual skills, the subject should be given novel instances of concepts to classify, or novel situations in which to apply a principle. Since production systems underlie these skills, if the subject is able to do so, then it is assumed that there is a production system in place that supports such action.

Think-Aloud tasks--In these tasks, the subject is asked to speak aloud his or her thoughts as he or she solves a problem or carries out an activity. The statements should be roughly parallel to the "code" of the production systems, and should follow the same logic. This was used by Gordon (1961) in his attempts to map out creative processes in inventors. Critics of the approach say that speaking aloud may interfere with the actual production system, by making the subject self-conscious of otherwise unconscious mental activities.

Diagnostic tests--By carefully creating tests that measure the components of a process (rather than just the outcome) the production systems that are used by the subject can be inferred. This type of test is common in mathematics, when students are asked to "show your work." The teacher can then reason that because certain steps were omitted or incorrect, that these productions (or links to these productions within the overall production system) are faulty.

EPISODIC/ICONIC/SPATIAL REPRESENTATION

Scanning time--If knowledge is structured in a pictorial form, then it should take more time to scan a complex image than it would to scan a more simple image. This type of test asks the student to recall a particular image (for example, how many panes of glass there are in your bedroom windows). The time that it takes to answer is highly correlated with the complexity of the image (number of panes of glass), therefore supporting the idea that the subject actually "looked" at an image that was stored in memory and actually counted the panes of glass. (E. Gagne, 1985).

Cognitive maps--It is assumed that cognitive maps are independent of language and semantic representation because monkeys and white rats also have them (Eysenck, 1987). Tolman first measured the existence of these structures by placing animals in mazes, allowing them to run free, then placing rewards in various places while blocking off certain avenues (LeFrancois, 1982). Because the animals still chose the shortest path, Tolman reasoned that they used "maps" to find their way instead of stimulus-response chains or sequences.

Human mazes--To determine the subject's spatial abilities and sense of direction, subjects are put through a disorienting situation and then asked to point to a direction or object. In a 1977 study by Kozlowski and Bryant (cited in Smyth, Morris, Lvy, and Ellis, 1987) subjects were put though a maze consisting of tunnels beneath a university. The students with better sense of direction were able to improve their ability to indicate the starting point over several trials. Those with weaker sense of direction are unable to improve. Witkin's field dependent/field independent aptitude was assessed an an attempt to determine why WWII flyers sometimes got lost in the clouds. His earliest test used a movable chair and movable horizon (room) to determine whether subjects were able to spatially orient themselves to true vertical. Later tests expanded his original concept (Witkin, Moore, Goodenough, Cox, 1976).

Mental rotation tasks--A subject is given two pictures of an object, and asked to determine whether or not the first object can be rotated to look like the second object. This can be done with two or three dimensional pictures. Because it takes longer to answer the question the further the actual object would have to have been rotated, one determines that a form of spatial or pictorial knowledge structure exists. (E. Gagne, 1985; Smyth, Morris, Lvy, and Ellis, 1987).

ISSUES

In critiquing the general problems with most cognitive theories and indirectly the issue of increasing the construct validity of cognitive structure, Thorndyke (1981) has said that we need theories that are capable of making predictions that more clearly separate one theory from another. J.R. Anderson (1976) has called this the problem of nonidentifiability (E. Gagne, 1985). Interested readers should review these sources for a look at this continuing argument, which basically says that empirical findings can often be accounted for by several different theories.

In terms of these assessment techniques as a method of assessing the contents of an individual's cognitive structure, Nagy (1983) has called cognitive structure measurements "a blunt instrument." The next step is a method of determining the reasons for the links, connections, or similarities. Although this type of linkage labelling is dealt with in Nowack and Gowan's concept mapping procedure, few of the other techniques listed deal with this issue. Nowack and Gowan (1984) themselves state that, " how accurately concept maps represent either the concepts we possess of the range of relationships between concepts we know...can only be conjecture at this time." Although Jonassen's method of pattern noting has concurrent validity with word association tests, the construct validity of word association tests is still arguable.

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Title:

Empirical Fact or Social Fact?

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Abstract

This paper examines the possibility of a Kuhnian paradigm in research on educational communications and technology. It discusses Kuhnian metaphor and its attraction as a viewfinder. It turns to anthropology for explanation of how beliefs and behaviors become social fact. Then it takes a critical look at usage of this metaphor in the field as a social text. It concludes by discussing the schism between researchers and practitioners in the ways they know the world.

Empirical Fact Or Social Fact?

Kuhn's metaphorical book *The Structure of Scientific Revolutions* (1970) has itself become a metaphor since its first publication in 1962. Kuhn used citation analysis, an empirical historical method, for building his model of how empirical thought develops in physics and astronomy. There is irony in empiricists from other disciplines borrowing his model for they do not apply his methodology. They account for their own fields with rational tools they would not normally allow in their work due to lack of empirical rigor. Invoking the authority of the Gospel of Saint Thomas Kuhn is no rarity in the second half of the twentieth century. The scripture of revolution has been adopted as the text for business as usual. The metaphorical structure has diffused from describing scientific research to the point that it applies to almost any perceived state or desired change, including improvements in computer operating systems. Perhaps the dying metaphor will receive burial when it becomes a household word. I imagine the day when advertising copywriters use *paradigm shift* as a replacement for *new improved classic taste.*

Empirical Mythology

Scholarly Knowledge About Educational Communications And Technology

The twentieth century disenchantment with epistemology, with metaphysics, and with philosophy as the guiding light of the sciences has resulted in confusion. Logical empiricism claims objectivity but fails any test of neutrality because science in action is a sociopolitical business with sociopolitical aims. Social scientists intend to understand social facts but seldom know why those facts have been selected for study or, indeed, how their discipline creates social facts. Scholars of education borrow theory and methods from these researchers. Confined by social discontinuities, the field of educational communications and technology cuts across education.

Social Facts

There are two kinds of human action, writes Suchman in describing the large contribution of G. H. Mead to her theory of situated action (1987). One is actually acting and the other is derivative in that it plans for the future and retrospectively accounts for the past. These projections or reconstructions become the social facts. The social text is not mere discourse but becomes part of the action. Rabinow looks specifically at scholarly representations as social facts (1986) and this is a recurrent theme in contemporary cultural anthropology (Clifford & Marcus, 1986; Geertz, 1973, 1983, 1988). These social facts are interpretations. In contrast, cognitive scientists should have difficulty with this concept because they accept words as equivalent to the objects they denote. Winograd and Flores (1987) have given the name *naïve realism* to this commitment to rationalism.

How Do Beliefs And Behaviors Become Social Fact?

Harris has proposed a theory of cultural evolution that accounts for how beliefs and behaviors are formed in response to environmental pressures (1968, 1983). There is no good reason to expect that intelligent life grows and reacts in the same way that mold on a crust of bread grows and reacts. Harris' theory of cultural materialism explains that beliefs and behaviors are shaped by the fundamental issues of food supply and population growth (1985). He has also extrapolated his theory to hyperindustrial American life (1987). His theory will be used later in this paper to show that claiming a paradigm of educational communications and technology performs a social function.

An Empirical Factfinding Mission Towards Prediction

Ever since the visual education movement emerged in the 1920s due to the frequent installation of motion picture projectors in schools, researchers have been concerned with justifying the pretheoretical assumption that technology can improve instructional effectiveness and efficiency. They act in accord with the scientific management reforms described by Callahan (1962) and Cuban (1986, p. 86-88). In a landmark investigation funded by a $10,000 grant, Freeman supervised the 13 studies reported by his assistants (1924). Their results suggested that visuals convey a different kind of information from that conveyed by language. Under the sponsorship of the Eastman Kodak Company, he disregarded his own conclusions and conducted a widely publicized media comparison experiment (Wood & Freeman, 1929). Over a period of 12 weeks, 20 films were shown to 11,000 children in 12 cities. Wood and Freeman had the 80,000 test booklets scored and found that film students provided more concrete answers to descriptive questions while giving answers to abstract questions that were equal to those given by the control group. This quantification justified educational motion pictures as a panacea and fitted in with the agenda of Freeman's dean, Charles Judd–see Clifford and Guthrie (1988, p. 78)–for establishing a science of education.

The tradition of experimental psychology in our field is the basis for claiming a cognitive paradigm. This reductionist line of research continued for over 65 years with spurts of excitement as each new medium appeared, see Dale, Dunn, Hoban Jr. and Schneider (1937), McClusky (1950), Saettler (1968) and Wilkinson (1980). In 1970, Heinich announced in his monograph *Technology and the Management of Instruction* the replacement of a behavioristic paradigm based on objective, observable behavior with a paradigm for learning theory. Clark and Salomon (1986) document this as a reality but unlike Heinich they do not refer to Kuhn. Clark and Sugrue reviewed the last decade of research on instructional media and identified four types of research: behavioral, cognitive, attitudinal and economic (1988). Their narrow perception of paradigm shift in educational media centers on "the new cognitive theories of learning from instruction" with achievement as the dependent variable. Winn expresses a strong belief in learning as the "bottom line" (1988, 1989) and so does Clark (1989). By learning they mean the transformation of individual minds and not the social process. Ironically, those who profess the cognitive paradigm are also charged with giving stamps of social approval to the practitioners who design and administer instruction. No wonder Winn writes, "...there has always been opposition within the field to research and theory that has at times bordered on hostility." (1988, p. 808).

Understanding The Transmission Of Culture

A crack is showing in the cognitive egg but no chick is ready to hatch. In contrast to the traditional reductionist research, cognitive scientists themselves are objecting that the interactions which make up knowledge communication cannot be isolated from situational dimensions (Suchman, 1987) and cultural fabric (Lave, 1988). From this viewpoint, sociocultural research apart from the mainstream represents a strength of educational communications and technology's position as an applied field.

The scholars investigating this dimension recognize that much more is at stake in educational communications and technology than achievement, which is only the ostensible purpose of schooling. Their work is closer to practice because it represents the need to solve real world problems. Driven by sociocultural research issues, their investigations cross the breadth of theories and methods of the social sciences and the humanities. For example, Belland, Duncan & Deckman (1985), Becker, (1986), Hlynka (1989), Januszewski (1988), Koetting (1988), Muffoletto (1987) and Taylor & Swartz (1988) are concerned about critically understanding cultural reproduction. They write in what Husen (1988) identifies as educations' other research paradigm: the humanistic way of knowing, as opposed to neopositivism/logical empiricism.

Kuhn's Gospel

A Stained Glass Window

Kuhn created his model to explain the results of his bibliographic research on the history of science (1970). His views opposed Popper's principle of falsifiability that had been accepted for three decades (Popper, 1968). In the Popperian tradition the research strategy competition in science is far from futile. It is thought advantageous because the credibility of steadystate knowledge rests not on dogma but on refinement and replacement by more powerful theories and closer approximations of truth. Popper, himself, had been a radical in asserting the superiority of empirical observation over the acceptance of scientific theories by agreement between authorities. Kuhn questioned Popper's textbook explanation of continual, rational progress.

Kuhn's scripture contains three central metaphors: paradigm, anomaly and revolution. The paradigm is an accepted set of rules for knowing about and conducting normal science. The anomaly is the exception that stimulates new explanations that cannot be ignored. The revolution is the emergence of a new paradigm.

Kuhn identified three normal foci of factual scientific investigation (1970, p. 25-30). They sometimes overlap and I have added the parenthetical phrases to improve the distinctions:

Determination of significant fact (applying research strategies).

Paradigmatic facts are developed for solving paradigmatic problems. Measurement occurs with increasingly refined apparatus and methods. Some researchers receive more recognition for developing research tools than for what they find.

Matching facts with theory (addressing research issues).

Increasing the match between theory and nature comes from arguments and/or factfinding demonstrations rooted in the real world: "The existence of the paradigm sets the problem to be solved."

Articulating theory.

A paradigm is articulated by looking for universal constraints, quantitative laws and experiments, in a more qualitative sense, that elucidate a phenomenon and relieve ambiguous interpretations.

This is not falsification (Kuhn, 1970, p. 77-80). New basic theories appear in the short revolutionary period of extraordinary science but new paradigms are incommensurable with previous paradigms. In the long periods of normal science, the reigning paradigm restricts researchers to puzzle solving science in which assumptions are not questioned.

Kuhn (1970) further questioned modern rationality by doubting the neutrality of investigators and suggested the importance of considering sociological and individual psychological aspects. He stated, "Lifelong resistance, particularly from those whose productive careers have committed them to an older tradition of normal science, is not a violation of scientific standards but an index to the nature of scientific research itself." (p. 151). This relativistic approach led to debates with other philosophers and historians of science including Popper, who defended the neutrality of scientists, and Feyerabend, who welcomed subjectivity and opened the back door to mysticism. Further debate with Lakatos chased empiricism into a corner and Kuhn demonstrated the importance of scientific consensus in determining hard facts (Lakatos & Musgrave, 1970).

Over the years Kuhn's bibliographic analyses increased in particularity because each revolution requires a unique explanation. His original metaphors did not fit all situations. For instance, he discovered differing paradigms for chemistry and physics that described helium either as an atom or as a molecule (1970, p. 50-51) and he drew parallels from science to art, from theories to painting styles (1977, p. 340-351). With refinement, Kuhn's model was reduced in scale from paradigms in conflict to theories in conflict. There is an admitted lack of generality, partly in response to close examinations of the issues, see the table illustrating Stegmüller's chapter on "Kuhnianism": Pseudoirrationalism and Pseudorelativism, (1976, p. 241-246). Barnes shows that Kuhn's ideas have become progressively more conformist, conservative and more supportive of the scientific establishment (1983). *Paradigm* has lost its revolutionary fire: it may mean no more than *Weltanschauung* as a metaphysical, epistemological and methodological perspective.

The Kuhnian Scriptures And Social Science

In examining the relationship of Kuhn to our field, it is first necessary to review Kuhn's influence on the social sciences, the source of our theories and research methods. Kuhn ventured "...it remains an open question what parts of social science have yet acquired such paradigms at all. History suggests that the road to a firm research consensus is extraordinarily arduous." (1970, p. 15).

What attracted Barnes to write on *T.S. Kuhn and the Social Sciences* (1984), despite Kuhn avoiding extrapolation of his ideas to the social sciences, was Kuhn's central argument that more is going on in science than an academic competition of ideas. Barnes describes the dangers of Whig history, of viewing the past as a reflection of the present, and of writing textbooks that present only facts that support current understandings. He also uses the phrase "intellectual laziness" (p. 120) to show that he does not endorse the dogmatic acceptance of Kuhn's model as an after the fact explanation in sociology, economics or psychology.

Kuhn (1970) cautioned:

"The members of all scientific communities, including the schools of the "pre-paradigm" period, share the sorts of elements which I have collectively labeled "a paradigm." What changes with the transition to maturity is not the presence of a paradigm but rather its nature. Only after the change is normal puzzle-solving research possible." (p. 179).

This is not enough. Just as early psychological researchers had physics envy (Gould, 1986, p. 262-263) and some social sciences have been the subject of debates over whether they are really scientific or not (Kuhn, 1970, p. 160), the acknowledgement of a paradigm is socially desirable as a sign of a discipline's intellectual adulthood. Cognitive psychologists claim that understanding Kuhnian paradigm shifts in their field is central to understanding cognitive psychology (Lachman, Lachman & Butterfield, 1979). In linguistics there was a Kuhnian diffusion of ideas through a new generation (Gardner, 1986, p. 209). Even parapsychologists are attracted by the orthodoxy of Kuhnian metaphors (Barnes, 1983, p. 90-93; Radner & Radner, 1982, p. 62-67).

Mitchell (1979), an English professor, could explain why no area wants to be regarded as preparadigmatic:

"We can always tell which of two crafts outranks the other by looking at its lexicon. Jargon only runs downhill. You will notice that although educators have borrowed "input" from the computer people, the computer people have felt no need to borrow "behavioral objectives" or "preassessment" from the educators." (p. 106)

The Cognitive Paradigm Metaphor As A Social Text

As the author of a classic work, Kuhn has endured the fate of classic authors in that his scripture has been more often cited than read (Adams & Searle, 1986, p. 381). This can be understood in the same way Johnson-Laird (1988, p. 21) debunks Lévi-Strauss and Piaget: "A theory may be so rich in descriptive possibilities that it can be made to fit any data." In other words, "Even things that are true can be proved," (Wilde, 1891/1976, p. 5).

The cognitive paradigm in educational communications and technology is a social text that encourages cooperation in the joint productive effort like the boost in agricultural production from a Kwakiutl chief redistributing wealth at a potlatch (Harris, 1974) or the feast of a Solomon Islands mumi (Harris, 1977). Having a paradigm is an indication of being established. The transition from preparadigm state to postparadigm state is widely perceived as the passage of puberty for any discipline. From the viewpoint of cultural evolution, claiming a paradigm has adaptive value. It helps people obtain and maintain employment. If they say they are believers they increase their chances of survival in the job market. Conflict is discouraged because it decreases material growth. Allowing people to examine what they do and why they do it causes schisms and these reduce the centralized power. Grandiose claims impress other big men[1] such as granting agencies and they reassure school district superintendents and corporate directors of instructional systems that someone really knows what is going on. Everything appears under control and the scholars who claim a cognitive paradigm on the elite campuses promise to bend their research efforts to everyone's benefit.

Another interpretation fits just as well because the same social mechanism could exist without actual paradigmatic consensus. If there is a Kuhnian paradigm in educational communications and technology, why does it mimic what Apple and Weiss (1983, p. 3) call the dominant, achievement measuring tradition of educational research? In Kuhn's scripture, preparadigmatic research is characterized by the atheoretical factfinding characteristic of prescientific times (1970, p. 15-16). Explanations of phenomena are inadequate. Data are too dense for decoding. Details are missed which are later considered important. In preparadigmatic research, technology is the name given to solving practical problems systematically. Technology mothers science.

In our field the technique is the systems approach to instructional management, also identified by Heinich as the result of paradigm shift (1970). Today the technique is known as Instructional Systems Development (ISD). The field has become more complex in the two decades since Heinich's observation and choosing between prescriptions is increasingly difficult. In a recent study, 30 ISD models were identified and compared for 12 major tasks (Taylor & Doughty, 1988). Further, Reigeluth (1989) warns that research and development may be out of touch with each other.

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[1] This phrase comes from anthropology.

Alternatives To The Received Research Agenda

From the cultural materialist point of view, individuals and groups can still use their intellect to choose what they want to believe and what they want to do. Harris thinks that despite lack of evidence of this in the past, it may be the only hope for our planet in the face of the ecological emergency (1987, p. 181-183). In our field, for example, we might turn aside from the mechanical study of achievement and select the direction of Habermasian morality:

"...education should function, via communicative action, to help us competently reach understanding with one another (the cultural function), fulfill appropriate societal norms (the social function), and develop our personalities (the socialization function), and in the process, learners become involved with objective, practical and emancipatory forms of knowledge." (Nichols, 1989, p. 9)

As a further example of an alternative to measuring achievement, I suggest looking for the special contributions of educational media in giving learners experiences which they can shape for themselves. I suggest evading the politics of schooling by finding ways of preventing the arbitrary constraints of time and place from interfering in individual learning. Also, I encourage educators to take an ethical stance and accept that achievement differences are not only unimportant but they are to be expected as normal and healthy. Achievement differences among the normal population not only do not need to be overcome but they should not be overcome.

The Schism Between Researchers And Practitioners

As an applied field, the Kuhnian paradigm of revolutionary process does not fit educational communications and technology and neither does the falsificationist myth of orderly progress. The description of the preparadigmatic state may fit equally well or even better. Nevertheless, Kuhn's contribution in identifying the sociopolitical underpinnings of science remains and there are material pressures for *claiming* a cognitive paradigm. That claim is a social fact, whether it is true or not.

The research base of educational communications and technology is scientific but the practice is not the practice of science. Technological determinism has a circular logic: Instructional science resembles medicine which is an applied science (Reigeluth, 1984, p. 20) but education is also claimed as an art (De Landsheere, 1988, p. 16). The split is well known from C. P. Snow's *Two Cultures* essay (1959/1965) and his semiautobiographical novel *The Search* (1935/1958). Hlynka argues for the necessity of both approaches and both metaphors in our technological field (1984). There remains a paradox in that the practice of educational communications and technology is not the practice of education. Jonassen, for instance, writes: "Educational technology is the *science* of instruction..." (1984, p. 159).

The cognitive research paradigm is so concerned with product that it can have no meaningful response to process questions such as Apple's "Is the new technology part of the solution or part of the problem in education?" (1988, p. 150). For example, quantitative tests show significant differences between students' levels of computer anxiety (Glass & Knight, 1988) but reliable measurements do not support the validity of a construct (Cherryholmes,1988). The results have been applied without regard for their validity. The consequences of computer anxiety research reports provide evidence that technology is not neutral and that science can be used to dominate people.

The interaction between the design of things and the design of instruction reveals the politics of the received research agenda in educational communications and technology. Norman (1988, p. 40-43) believes that badly designed hardware and software teach people to be helpless when working with technological items. In contrast to that cognitive engineering viewpoint it is incongruous that the computerphobia programs deliberately teach people they are helpless. These interventions tell people they are ineffective and incapable and that they need special instruction to get over their disability. I disagree with these procedures and my values are probably similar to the ones you hold: I believe that things need fixing, not people. My comment is that the act of teaching teachers and students that they are computer anxious, that they are helpless, that they need remediation, may be an oppressive act. Sociocultural issues such as these need to be explored with research based on sound, theoretical foundations drawn broadly from the social sciences and the humanities.

Educational communications and technology is rooted in the practice of using and producing educational media but researchers do one set of things and practitioners do another set of things. Classroom teachers, school media coordinators and instructional system developers select images to convey the world to learners. They know the field is effective because educational media employ rhetoric. The field is poetic, lyric, dramatic, epic and alive with metaphors. Researchers investigate to write scholarly research reports but educational cinematographers investigate to create films and videos. The way of saying something changes what is said. In practice, far beyond the dusty educational psychology journals that fill shelf after shelf of university libraries, we have an artistic, creative, imaginative field.

Adams' *Philosophy of the Literary Symbolic* (1983) confronts the tension between the literary and the scientific ways of knowing: "The war between poetry and philosophy has extended from before Plato's time into our own." (p. 389). These words also apply to educational communications and technology. More than a paradigm, debates between researchers and between researchers and practitioners ensure conscious decisions. More than a paradigm, the field needs this conflict between the poetry of practice and the philosophy of research.

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Title:

Distance Education in the Teacher Education Program of Zimbabwe

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Introduction

A research project, utilizing both quantitative and qualitative methods, was designed and conducted to study the distance education component of the Zimbabwean teacher education program. During this study, in which the research design evolved during the project, a model combing three theoretical perspectives on education was developed by the author. This model, the Triad Perspective Model of Distance Education, integrates Systems Theory, Curriculum Development Theory, and Adoption and Diffusion of Innovations Theory. By using the model as a guide, a comprehensive description of the program was created, the strengths and weaknesses of the program were identified, and recommendations for program improvement were presented.

Zimbabwean Teacher Education

Background

Zimbabwe's current educational structure is a result of the shift from British colonial rule to independence in April, 1980. Prior to that time, public education was divided along racial lines, and schools were strictly segregated. The educational system was a way of "establishing and maintaining the social and economic differences between the black majority and the white minority" (Kadhani & Riddell, 1981, p.58).

Political upheaval eventually brought about major changes in the country's educational priorities. Upon independence, Zimbabwe was in a position to offer educational opportunity to all of its citizens, regardless of color. Unfortunately, the radical changes brought about by a new political philosophy could not be immediately assimilated and a "crisis of expectation" assaulted the schools. Enrollments increased dramatically, challenging the resourcefulness and ingenuity of Zimbabwean educators. Between 1979 (pre-independence) and 1984 there was a 262% increase in the number of students enrolled in primary schools. The expansion at the secondary level was even greater. Between 1979 and 1984, secondary enrollments increased by 638% (Chivore, 1986).

The number of professionally-qualified teachers employed in the Zimbabwean educational system could not begin to meet the need. In 1985, over 66% of the secondary school teachers were untrained or underqualified, and the situation was considered "critical" at the primary level, as well (Chivore, 1986). This shortage of qualified teachers led to major changes in the teacher education program.

Teacher Education in Zimbabwe

The original, pre-independence model for teacher education was quite similar to the traditional American model. Students attended a specialized Teachers' College for training, of which there are now fourteen in Zimbabwe. Teacher education consisted of a three-year campus-based program that included periods of "teaching practice" (similar to student teaching) with increasing classroom responsibilities over time, under the direct supervision of a full-time classroom teacher.

This model was altered in response to the teacher shortage that occurred after independence was achieved. The student's responsibilities while on teaching practice (T.P.) increased, as did the amount of time spent on the T.P. assignment. The current model, adopted in 1988, includes one year of on-campus instruction, one year of teaching practice (during which the teacher education students shoulder the responsibilities of full-time teaching), and the final year back on campus.

Another model of teacher education was created within the Zimbabwe Integrated National Teacher Education Course (ZINTEC). Four ZINTEC colleges were built shortly after independence specifically to alleviate the teacher shortage crisis by putting large numbers of teachers into classrooms after a short, intensive training period. The ZINTEC model, as it now exists, is a four-year program with two terms (four months each) of on-campus instruction, followed by eight terms of T.P., concluding with two terms on campus.

Distance Education and the Teacher Education Program

Distance education was incorporated into the teacher education program so that students on teaching practice assignments could continue their academic progress. The program has been predominantly print-based, utilizing self-contained "modules" for instruction. The students work from these learning packages and return assignments when visiting the campus for seminars or at the end of their T.P. assignment.

The modules are prepared by a central agency, the Distance Education Centre, with assistance from teachers' college faculty who are released on "sabbatical" to act as subject matter specialists. Because academic resources are often scarce in the outlying rural areas where many students are assigned to teaching practice, the learning packages contain the necessary reading materials and emphasize projects that can be completed with locally-available supplies.

Studying the Distance Education Program

A research project was designed with the purpose of developing a narrative description of the Zimbabwean distance education program's strengths and weaknesses. Recommendations for further development would then be drawn from these results.

With the assistance of a grant from the United States Information Agency, through its Teachers/Texts/Technology program, two trips were made to Zimbabwe by the author to observe the distance education program. In addition to observation, interviews were conducted and questionnaires distributed to assess the role and status of distance education in the teacher education program.

Triad Perspective Model of Distance Education

As in many qualitative studies, an "emergent research design" began to evolve as the project progressed. A model, developed from three theory bases, was created by the author to facilitate the comprehensive description of the distance education program. These theoretical perspectives were the foundation for the study and included Tyler's Curriculum Development theory (1949), Banathy's Systems theory (1973), and Rogers' theory of Adoption and Diffusion of Innovations (1983).

The core ideas within each of the three theory bases were incorporated into an integrated model, the Triad Perspective Model of Distance Education (TPMDE). (See Figure 1.) Each theory base represents a vertical column within the model. Curriculum Development is on the left, Adoption and Diffusion of Innovations is on the right, and Systems theory is in the middle (or "back", if visualized three-dimensionally). Each horizontal level of the model represents a frame of reference drawn from the relationships among the three theories. The uppermost level is "Environment;" the second is "Structure;" the third, "Process;" and the final level is "Evaluation." These four levels were the source of research questions that guided the descriptive analysis of the distance education program.

Some examples of research questions that grew out of the "Environment" level of the model included:

- What are Zimbabwe's educational needs?
- What relationships exist between the program and the environment?
- What are the goals and objectives of the distance education program?

The second plane of reference focused on the distance education program and its content and internal structure. Research questions included:

- What components constitute the distance education program?
- What are the functions of the various components?
- Are the components and functions working together to move the program toward its goals?

The "Process" level of the model was concerned with the behavior of the program over time and transformations

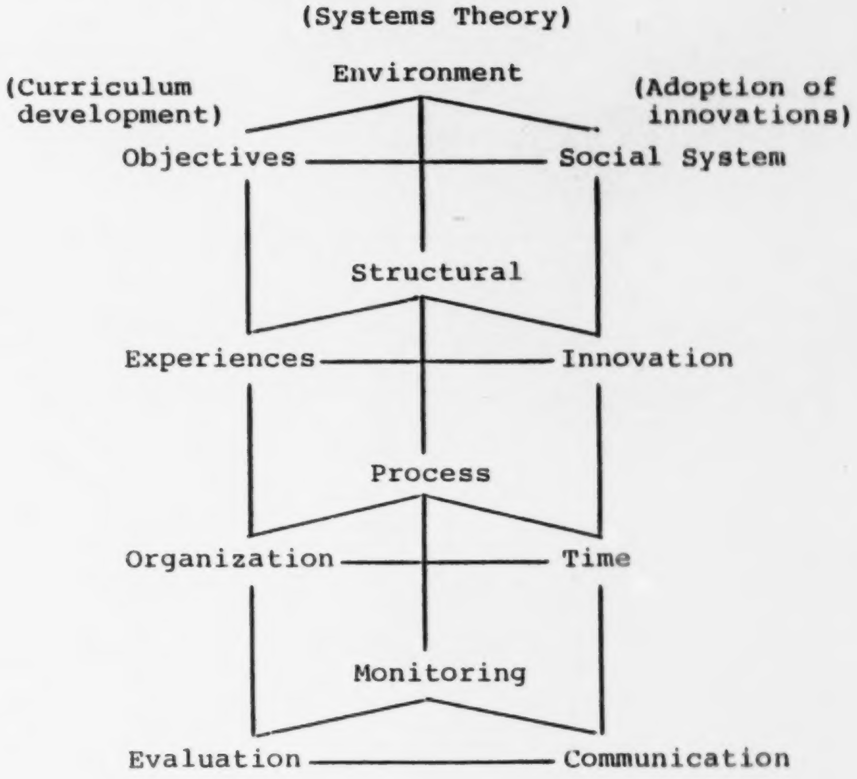
(Systems Theory)
Environment
(Curriculum development)
(Adoption of innovations)
Objectives
Social System
Structural
Experiences
Innovation
Process
Organization
Time
Monitoring
Evaluation
Communication

Figure 1. Triad Perspective Model of Distance Education (TPMDE)

that could affect the overall organization of program operations. Some research questions from this level were:

- How has the distance education program changed over time?
- How could purposeful change be introduced into the system?

The final level of the TPMDE, "Evaluation," is dependent upon the communication channels available among the system's components and also those supporting the system within its environmental context. The monitoring and regulatory capacity of the program was studied by asking:

- What communication channels are necessary for the successful functioning of the program?
- Is there a clearly identified process for program monitoring within the distance education program structure?

The flexibility of this integrated model allows the researcher to generate research questions related to a specific program, or to design a new program based on identified needs. In this study, a comprehensive description of the distance education component of the Zimbabwean teacher education program was created. The major strengths and weaknesses of the program were identified and recommendations for further development were given.

Strengths and Weakness of the Distance Education Program

There were five major strengths identified during this study. These were: purpose, history, Ministry advocacy, personnel, and students.

"Purpose" refers to the strength of the conviction within Zimbabwe's educational community that distance education was worthwhile and important to the success of the teacher education program. Initiated in response to a national crisis -- teacher shortage -- there was a minimum of resistance to this innovation.

The second strength identified was the program's persistence. Faculty members in the teachers' colleges were comfortable with the concept of distance education for instructional delivery. Distance education had historical precedent in several African nations and was considered a viable mode of instruction.

Ministry advocacy of the distance education component was the third program strength. As the administrative entity over the teachers' colleges, Ministry of Education support potentially could be translated into budgetary and personnel assistance. By recognizing the distance education component as a vital part of the teacher education program, official Ministry sanction also provided political endorsement for its continued existence.

The fourth strength identified was the quality of personnel involved in the program. The theoretical grounding and academic preparedness of these educators created a strong talent pool at each teachers' college. Although working under circumstances that might appear unreasonable in the United States (very large classes, few resources, etc.), lecturers spoke positively of their role in the educational system.

The quality of the students at the teachers' colleges was the fifth major program strength. Because there were many more applicants than program openings, the colleges were able to select students of high calibre that were most likely to complete the program successfully. These students were described by their instructors as highly motivated and dedicated, and those encountered by the author appeared articulate and mature.

The primary weaknesses of the program included the lack of a "Zimbabwean Model" for distance education, ineffective communication, lack of accountability, insufficient quantities of trained personnel, and lack of instructor/student feedback procedures. Each of these weaknesses was identified by using the TPMDE.

The lack of a unified model for distance education in the Zimbabwean teacher education program contributed to a lack of focus. Without uniformity of purpose, the distance education activities across colleges (and, in some cases, within colleges) were designed to achieve differing aims. This, in turn, led to inconsistency in programming and lack of equivalency across programs.

Lack of effective communication channels, the second major weakness, resulted partially from the lack of a unified model. Although some of the difficulty in communicating could be attributed to logistical barriers (e.g., poor telephone and postal service), much of the problem could be attributed to the system itself. Without an established structure to support the open exchange of ideas and information, channels of communication are unlikely to develop spontaneously.

The third weakness, lack of accountability, could also be related to the lack of a unified structure within the program. Because the distance education activities at each college were managed by individual departments, there was no centralized system in place to monitor the overall progress of the students. This made it difficult to substantiate the value of the program and undermined the credibility of its goals.

Although the program's personnel was considered a major strength, there were simply not enough of them -- a weakness that was consistent across all levels of the educational system. Lecturers and administrators who were on the job became overworked and were unable to provide as much individual attention to students as they would have preferred.

The fifth weakness -- lack of timely feedback to students -- had severe ramifications. Distance education projects and assignments had sometimes remained unmarked for weeks (or even months) and students were unaware of their progress. Instructionally, this was the program's most critical flaw, and understaffing and logistical barriers to interaction had aggravated the problem.

Program Recommendations

Based on the comprehensive description of the distance education component, a set of program recommendations was developed. These were:

- Establish a Distance Education Commission;
- Conduct program evaluations on a regular basis;
- Re-focus the distance education modules toward applied education;
- Encourage a more active role for the University of Zimbabwe; and
- Establish a Distance Education Department at each teachers' college.

Establishing a Distance Education Commission, to be convened by the Ministry of Education, would enhance the credibility of the program and increase the communication among the parties involved. This commission would serve predominantly in a consultative role and would make recommendations for program improvements based on the commissioners' collective expertise.

Conducting program evaluations on a regularly-scheduled basis was the second recommendation. These rigorous, objective evaluations could examine the cost effectiveness of the program, attitudes of students, perceptions of lecturers and administrators, quality of materials, and student achievement. Collecting program information regularly creates a base of research data that could be used to make long-term planning decisions and help to allocate limited resources efficiently.

The third recommendation was to modify the focus of the distance education modules, emphasizing applied education topics and practical aspects of teaching. This would enable the students on T.P. to utilize their classrooms for assignments directly tied to their daily activities. Another potential benefit of this modification would be improved teaching by the T.P. students and a stronger link between the theoretical topics covered in on-campus instruction and the practical realities of the classroom.

Increasing the University of Zimbabwe's involvement in the distance education program was the fourth recommendation. As the overseeing institution for teacher certification, a stronger leadership position was suggested. Some possible activities related to this would be offering courses about distance education for college credit, seeking out external funding sources for upgrading the distance education program, and consulting with individual teachers' colleges regarding research projects.

The fifth recommendation was to establish a Distance Education Department at each teachers' college. By centralizing operations in this way, program accountability would be facilitated and consistency across programs enhanced. Communication throughout the system would also be improved because there would be one individual at each institution that could "speak for the program."

Summary

By using the Triad Perspective Model of Distance Education as a descriptive tool, the distance education component of the teacher education program of Zimbabwe was studied. A comprehensive narrative detailing the strengths and weaknesses of the distance education activities was created with recommendations for further improvement. As educational access becomes increasingly important to traditional educational institutions, the role of distance education will expand. To this end, a solid research foundation must be created to guide decision-making for long term success.

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March 21,1991